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Zanesco et al.

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(54) **PORTABLE OBJECT COMPRISING A ROTATING CONTROL STEM WHOSE ACTUATION IS DETECTED BY MEANS OF TWO INDUCTIVE SENSORS**

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CPC G04C 3/004; G04C 3/005; G04C 3/007; G04C 3/14; G04G 21/08; H01H 36/006; H01H 25/06; H01H 19/00
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(74) *Attorney, Agent, or Firm* — Oblon, McClelland, Maier & Neustadt, L.L.P.

(57) **ABSTRACT**

A portable object including a control stem, actuation of which in rotation can control at least one electronic or mechanical function of the portable object, a magnetized ring driven in rotation by the control stem, rotation of the magnetized ring and position of the magnetized ring being detected by two inductive sensors configured to be sensitive to a variation in magnetic induction in only two directions in space that are parallel to each other or that converge on a
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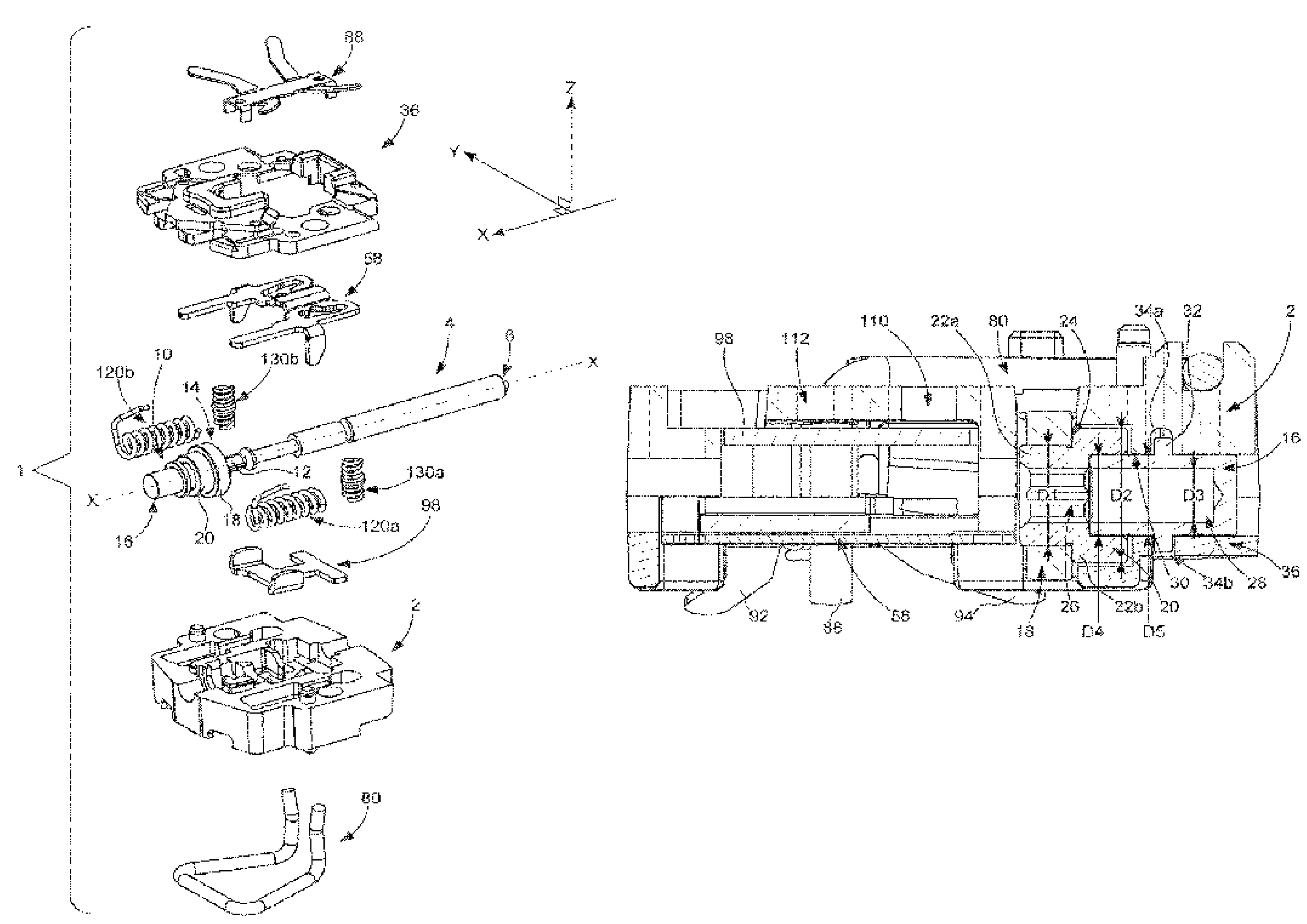

same point, with exception of a case in which these two directions are perpendicular to each other.

17 Claims, 12 Drawing Sheets

(58) **Field of Classification Search**
USPC 368/187
See application file for complete search history.

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Fig. 1

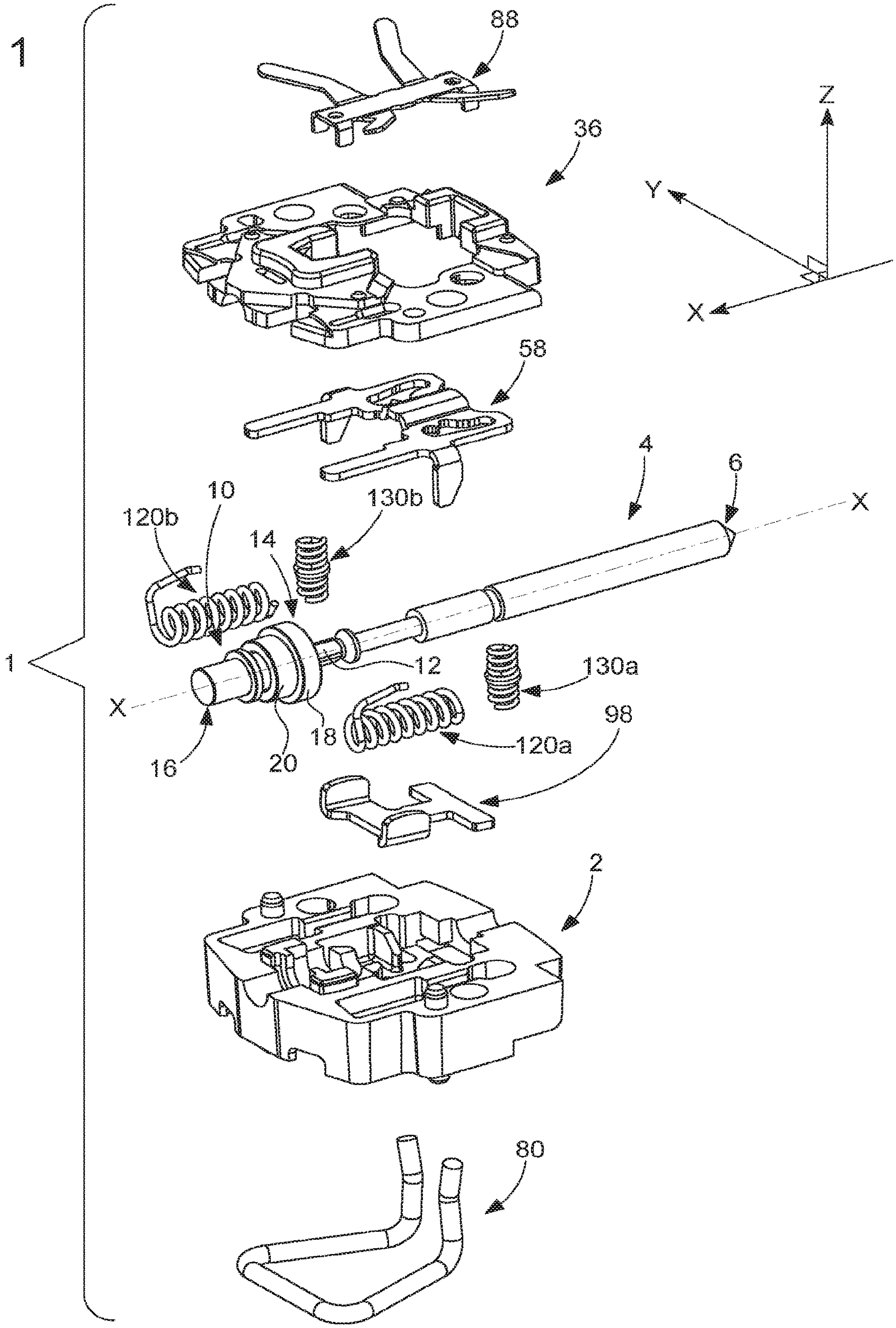
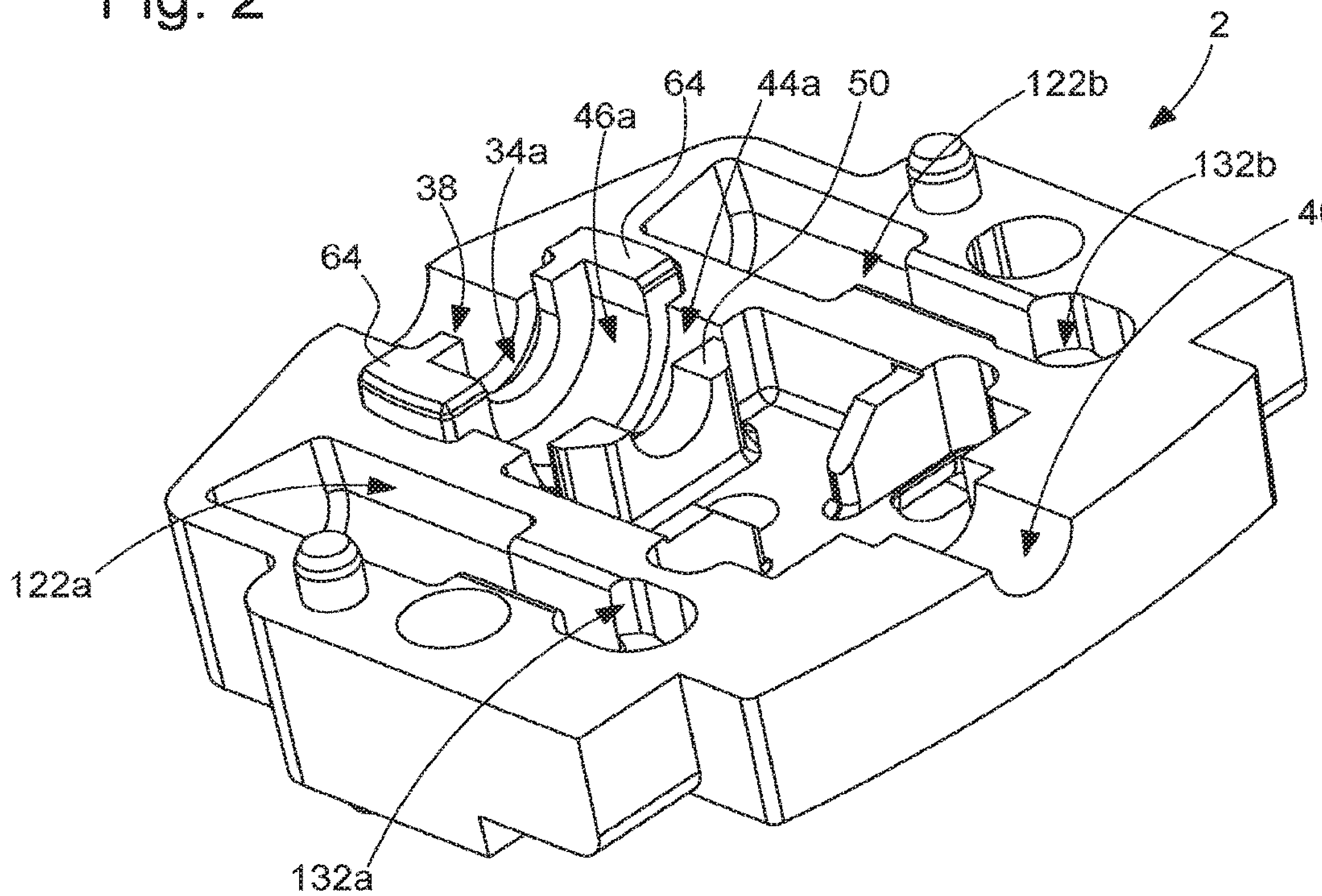


Fig. 2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34a
132b
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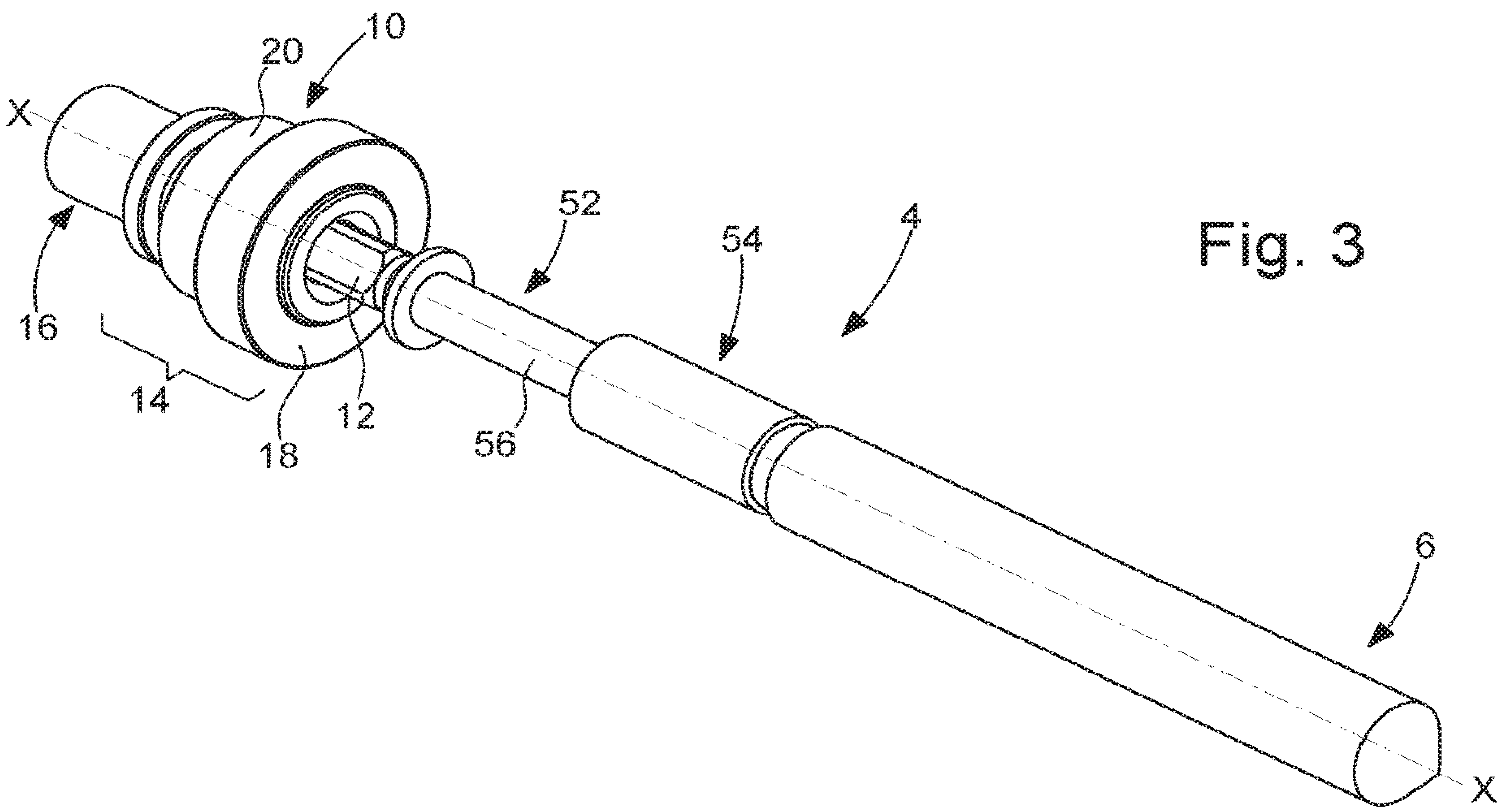
64
122a
132a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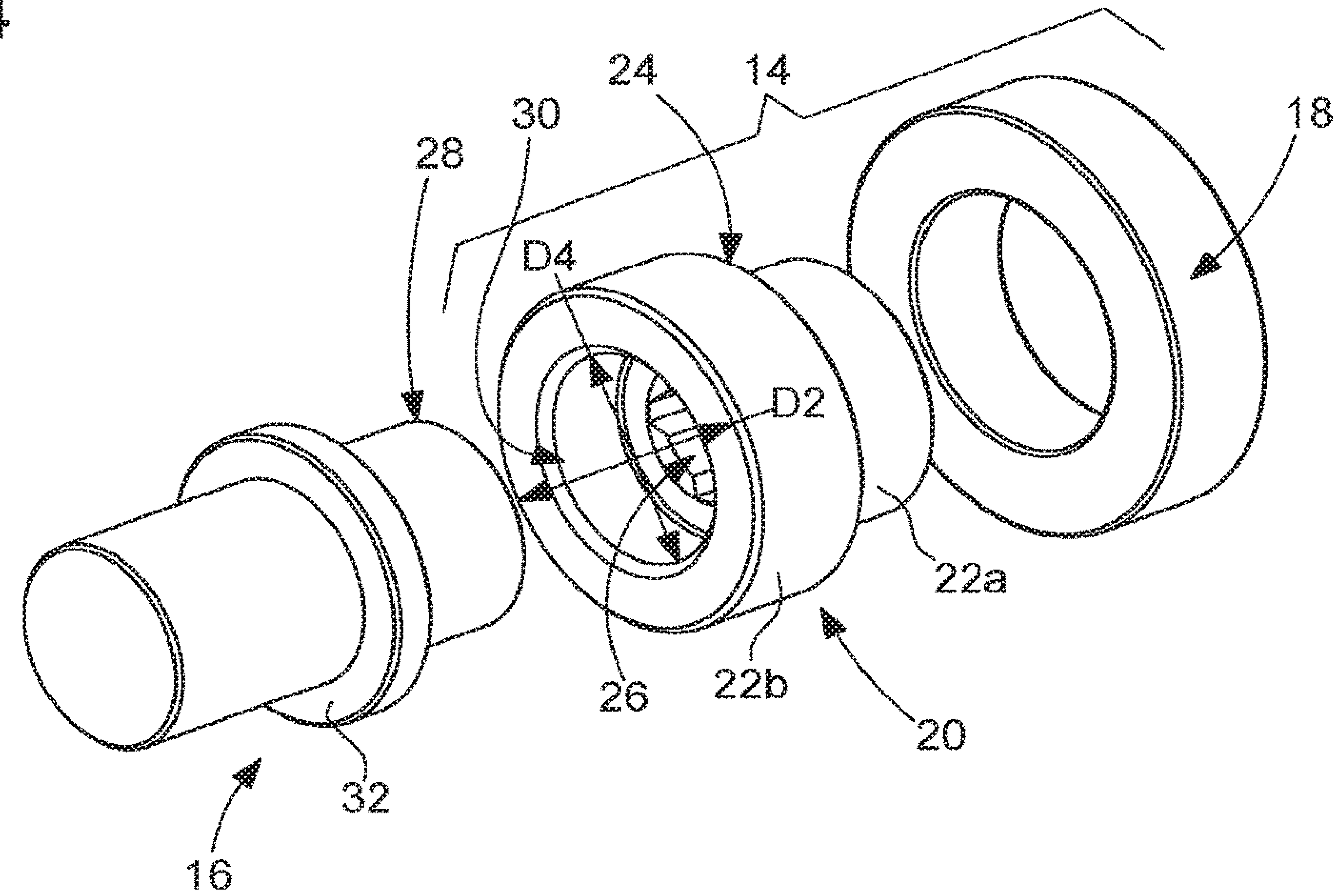
6
X

Fig. 3

Fig. 4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22b
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32
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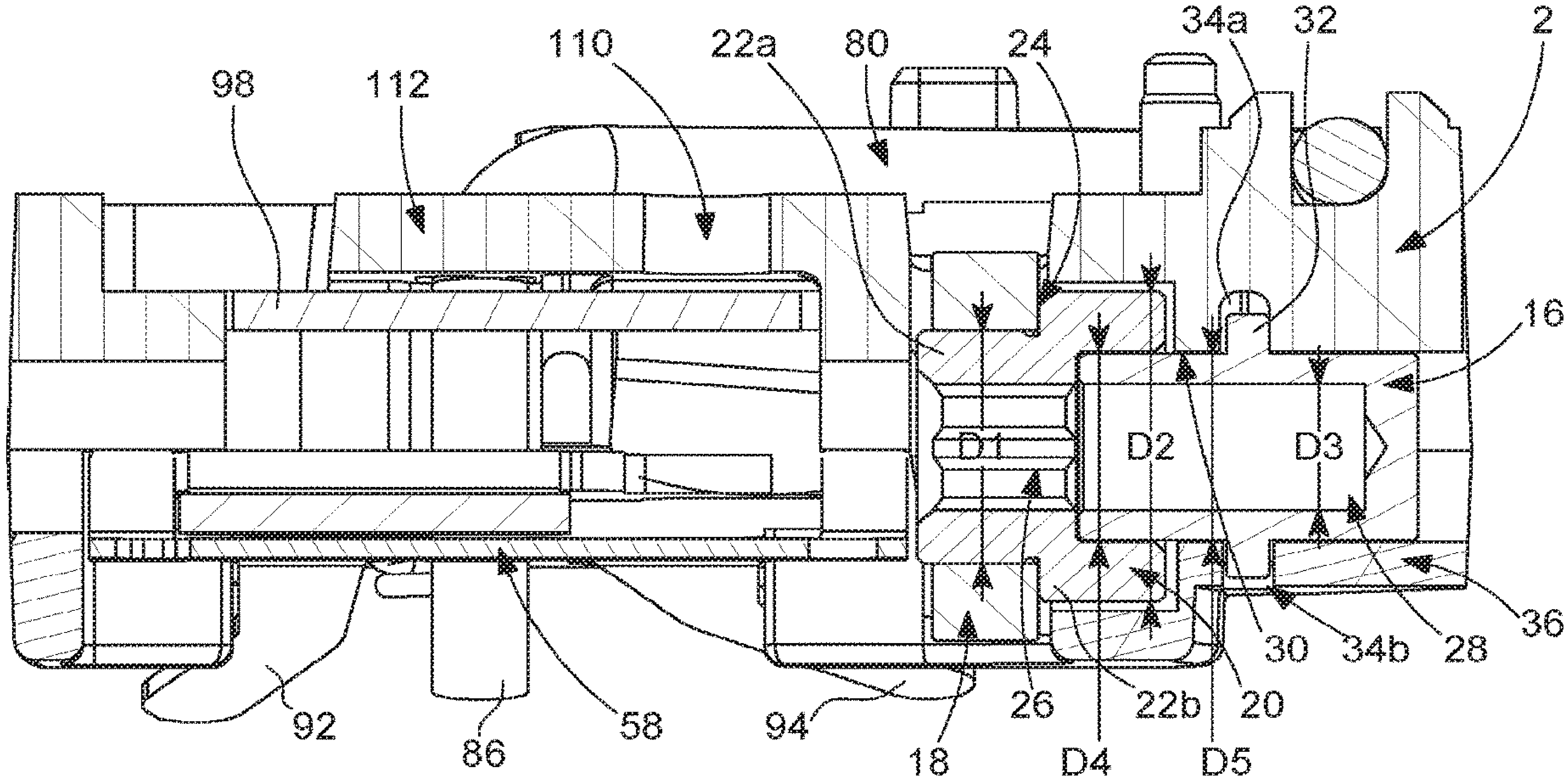
Fig. 5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22b
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D4
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34b
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Fig. 6

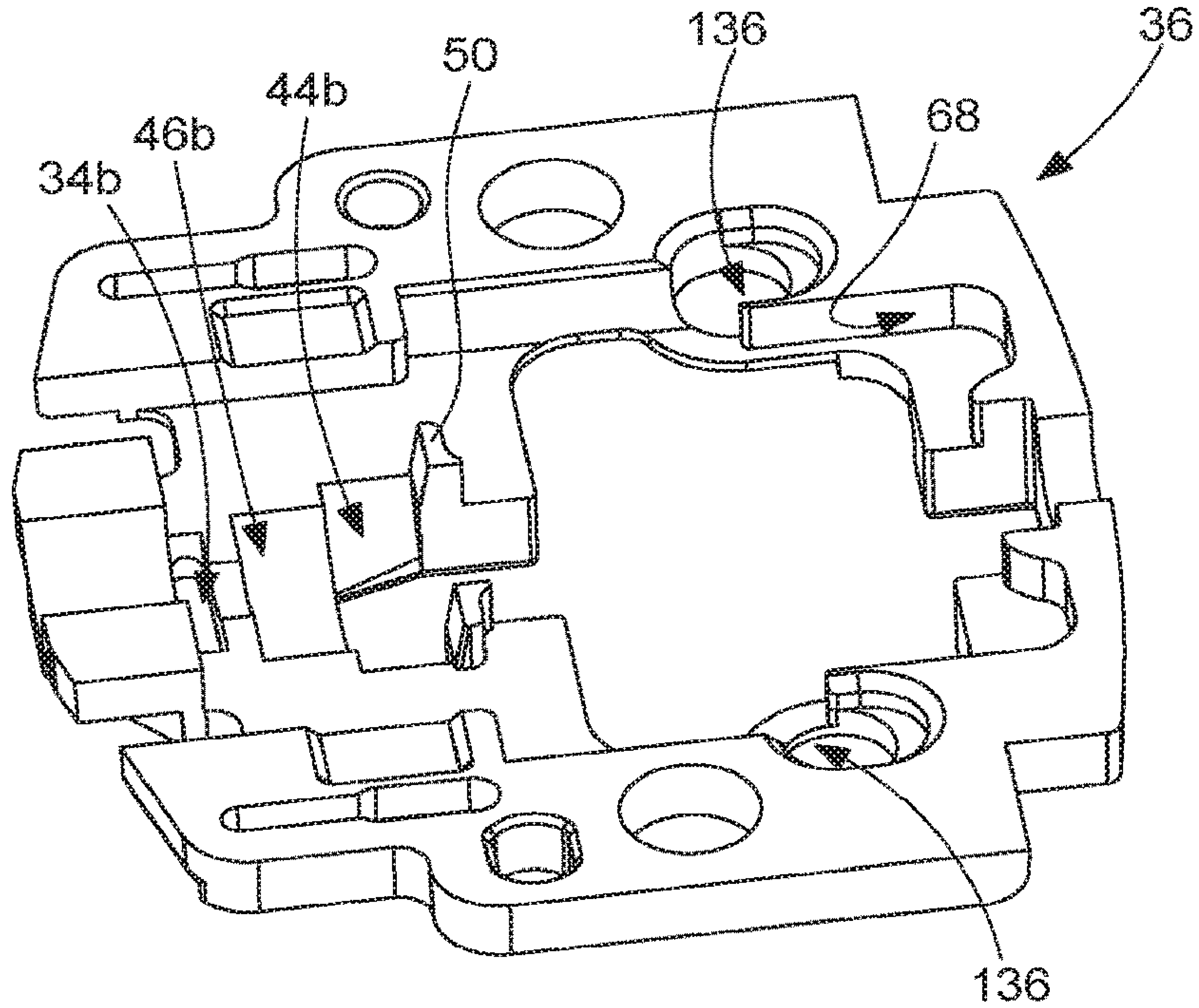


Fig. 9

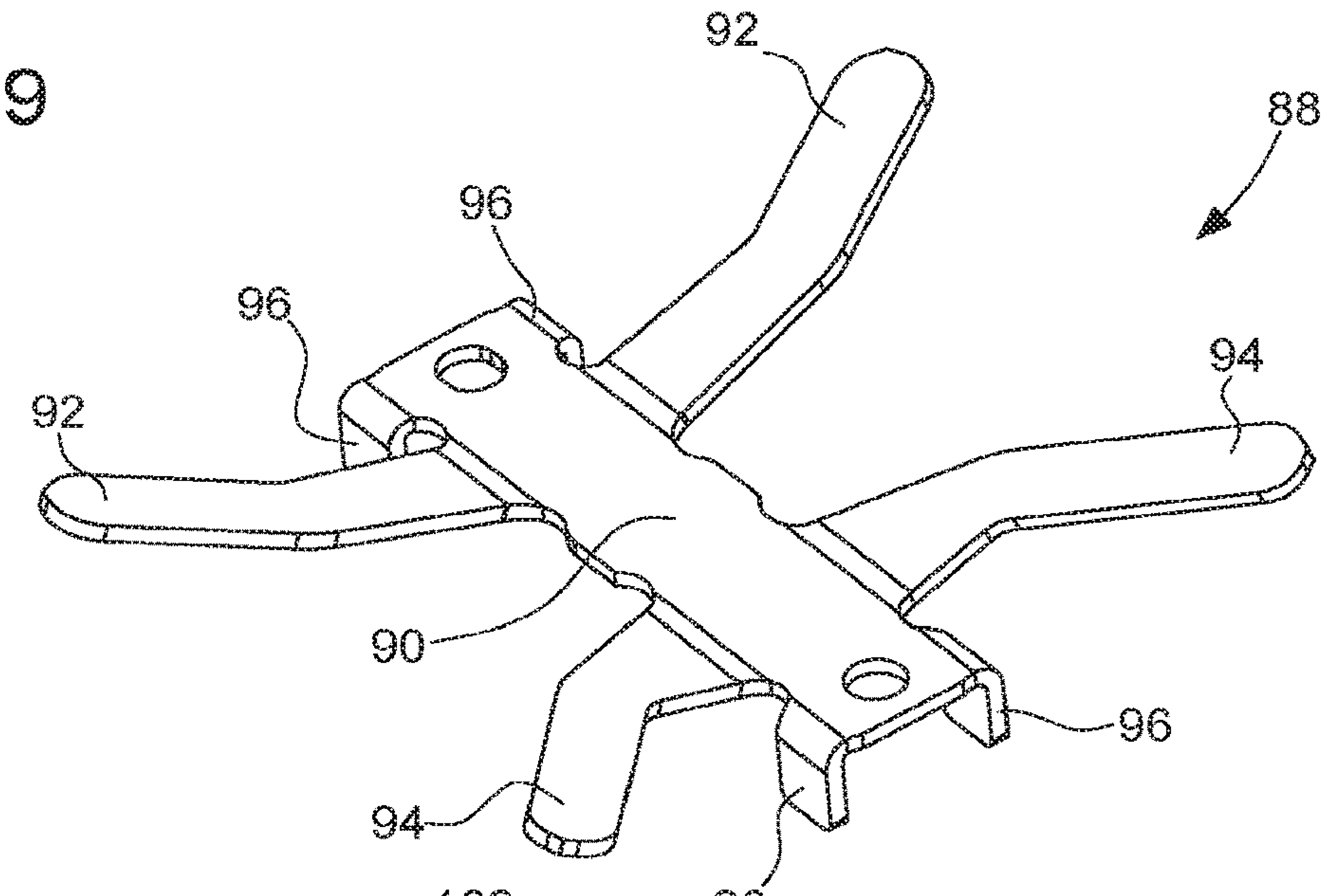


Fig. 10

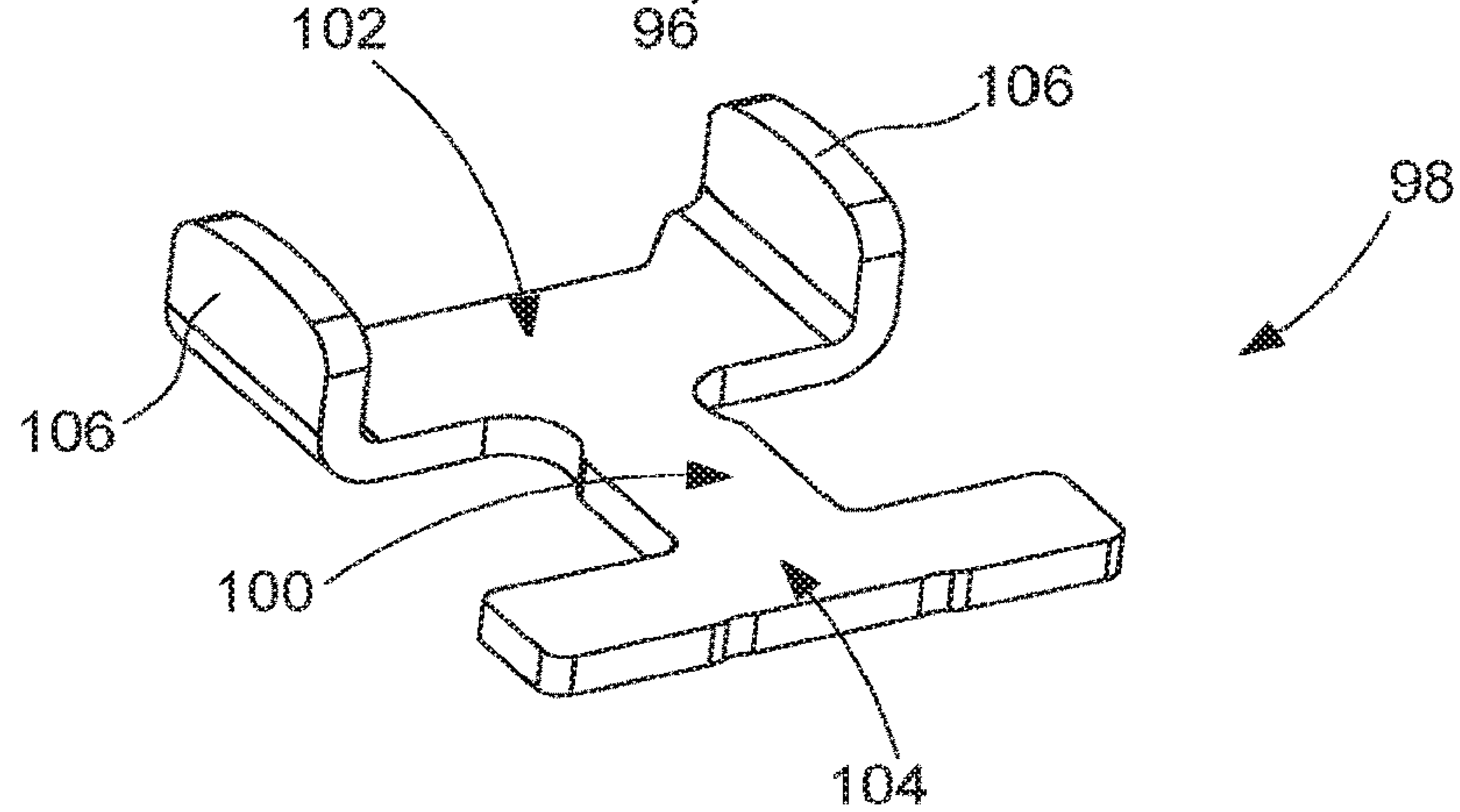


Fig. 7A

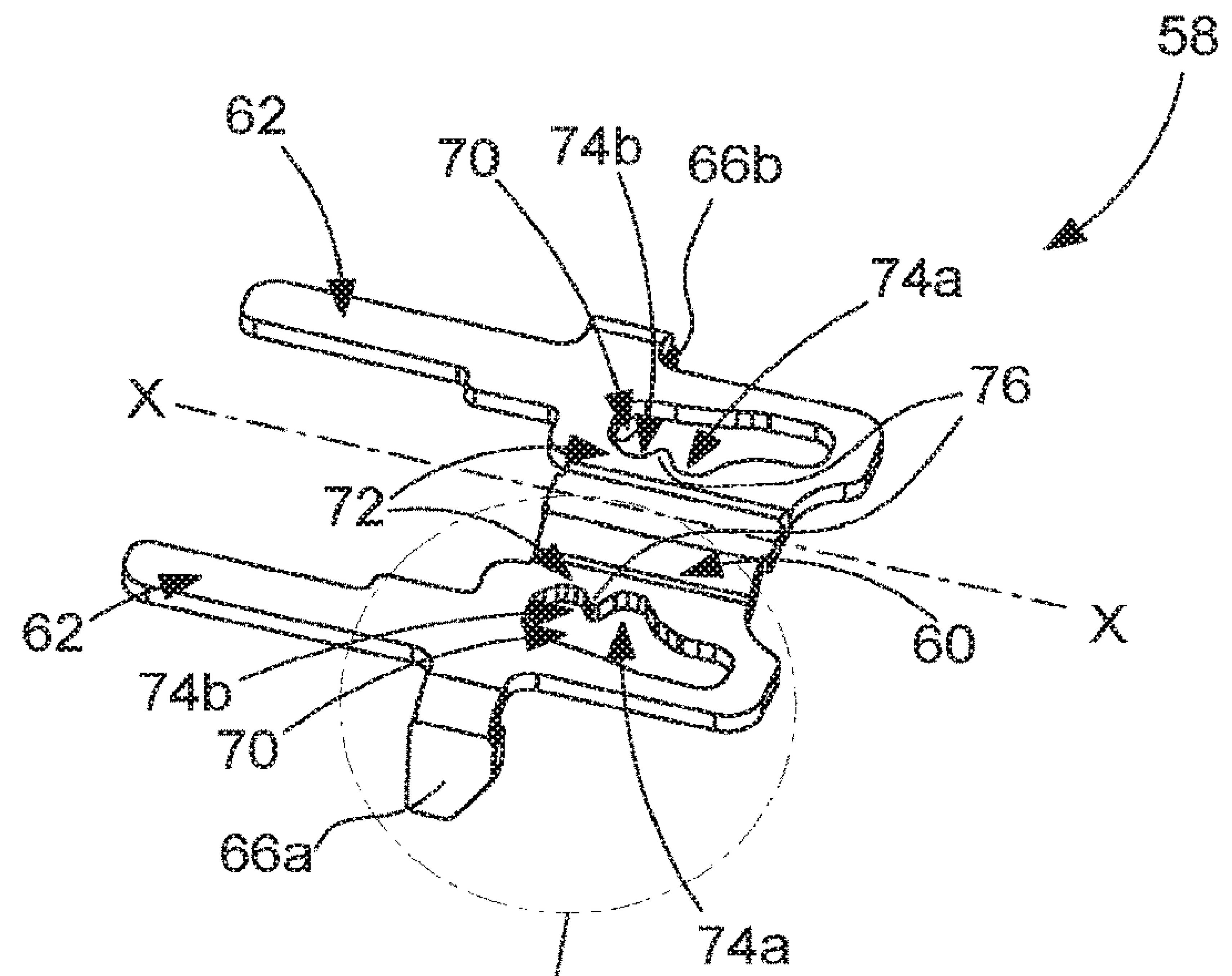


Fig. 7B

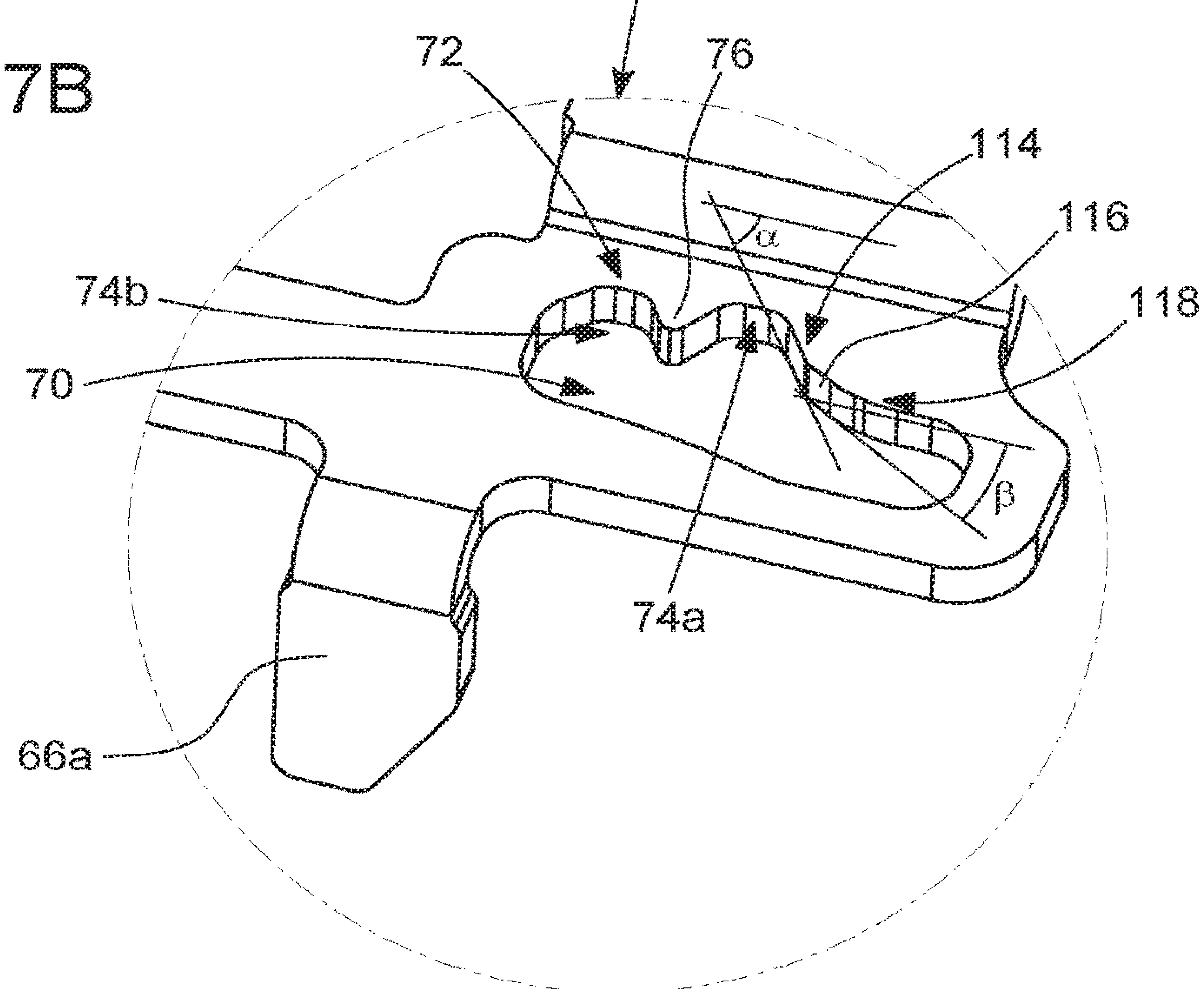


Fig. 8

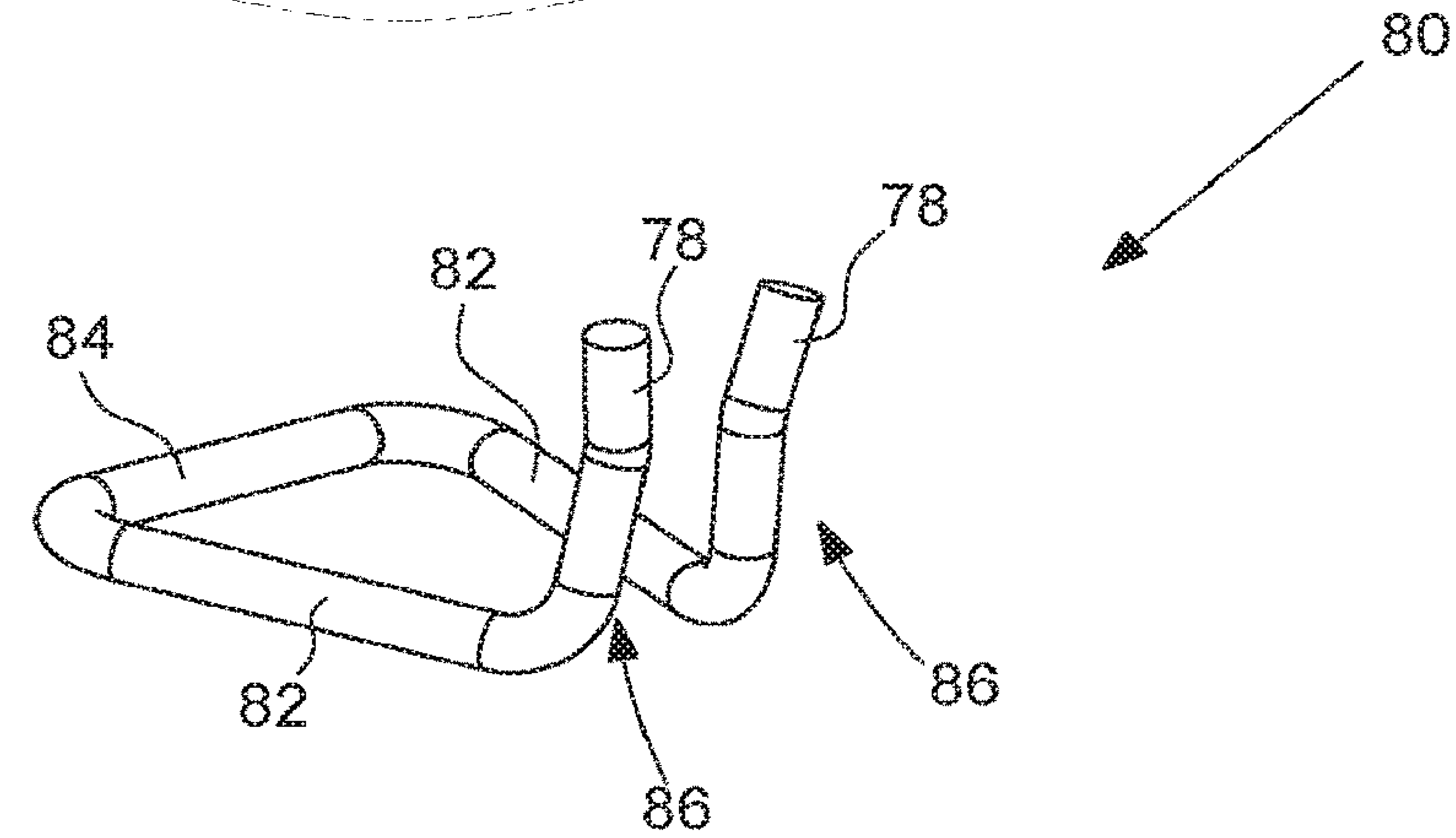


Fig. 11

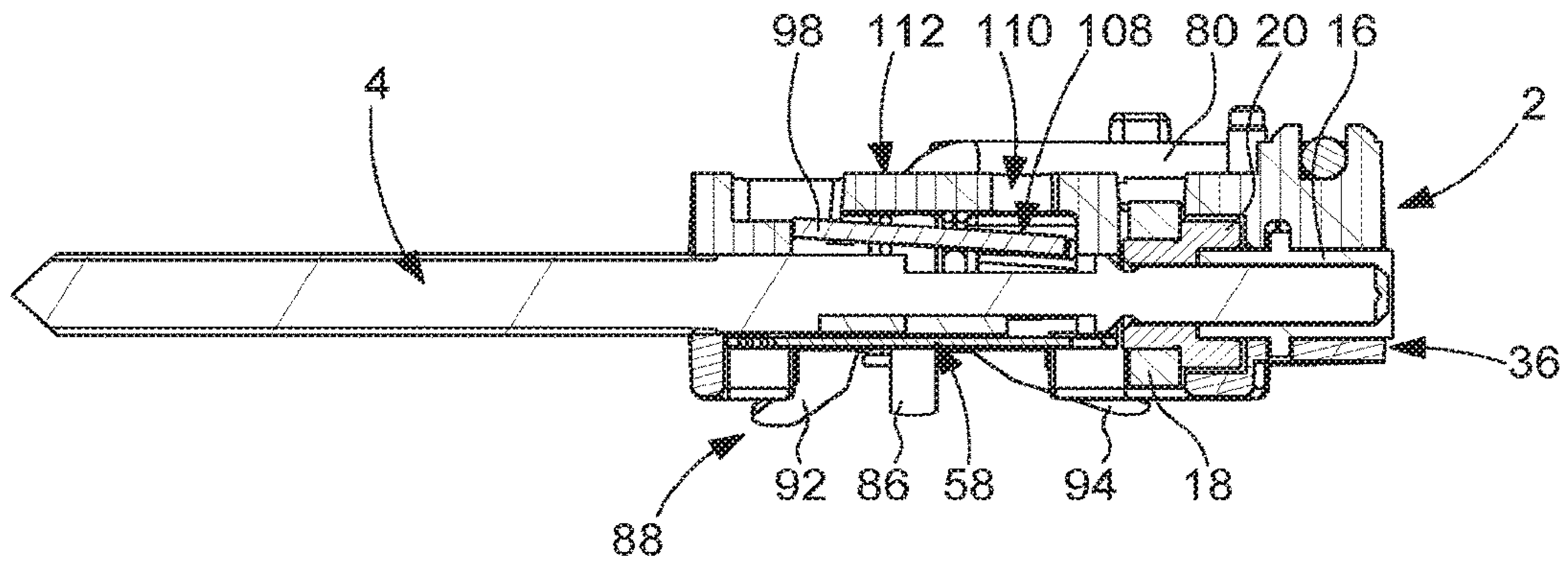


Fig. 13

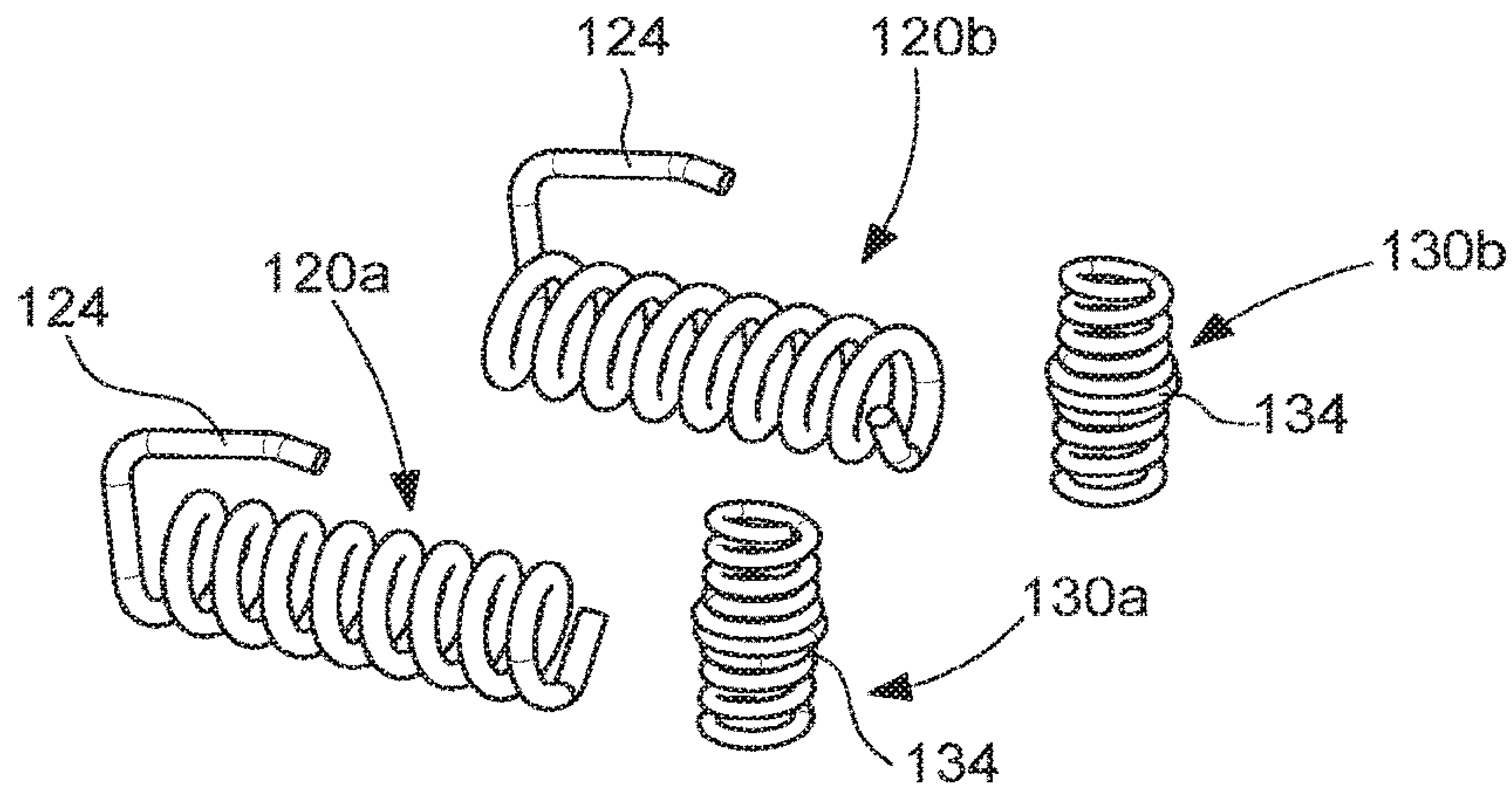


Fig. 14A

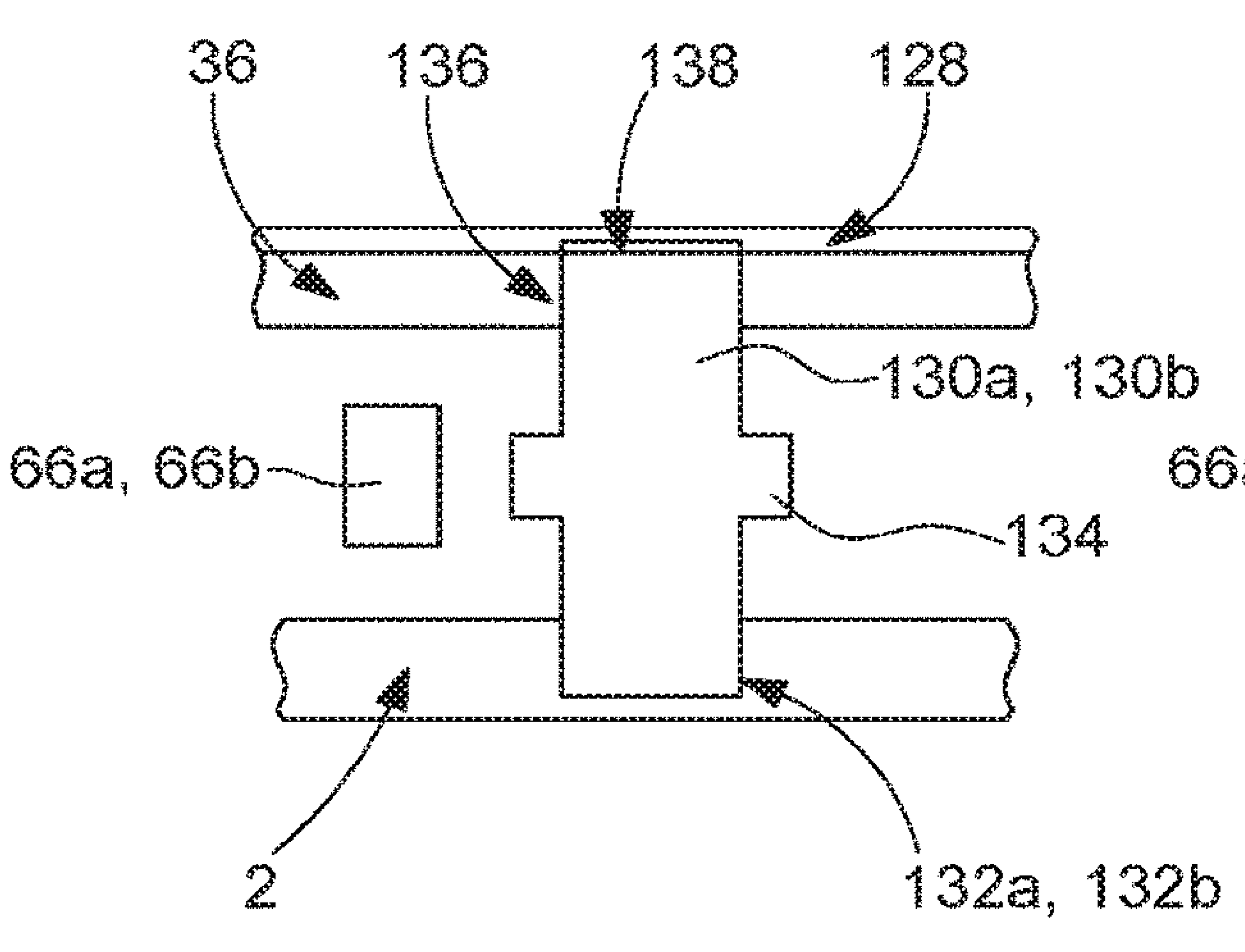
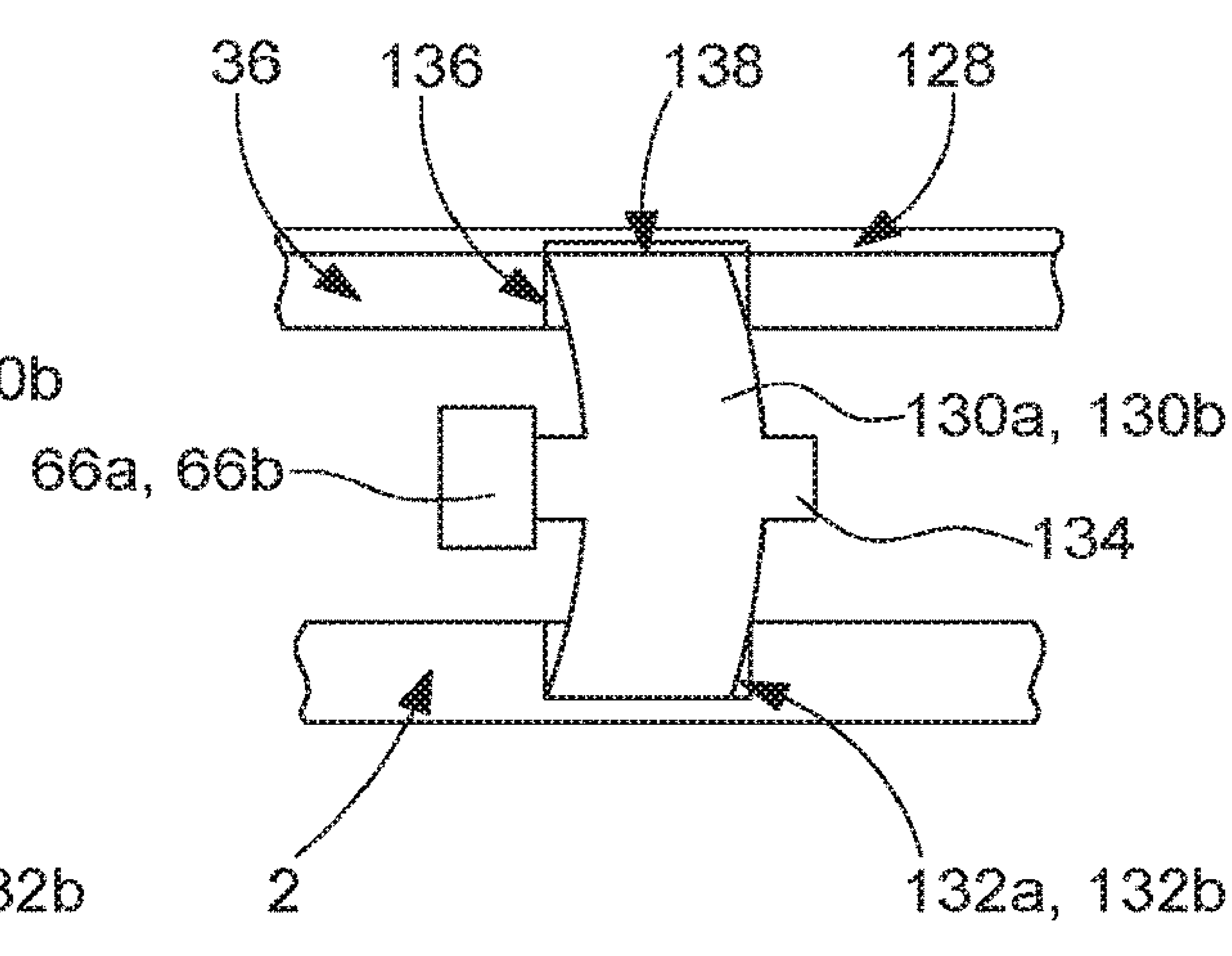


Fig. 14B



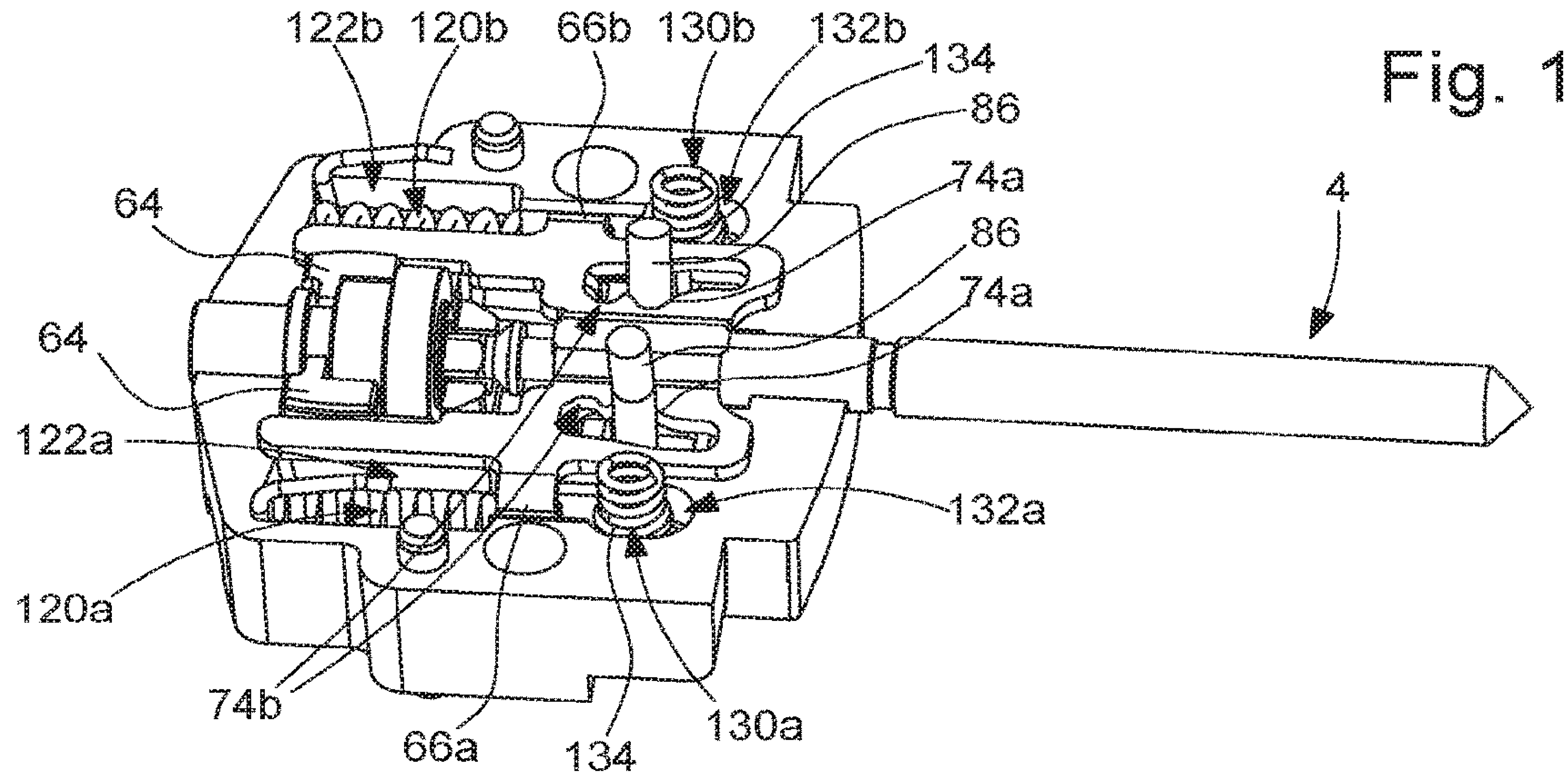


Fig. 12A

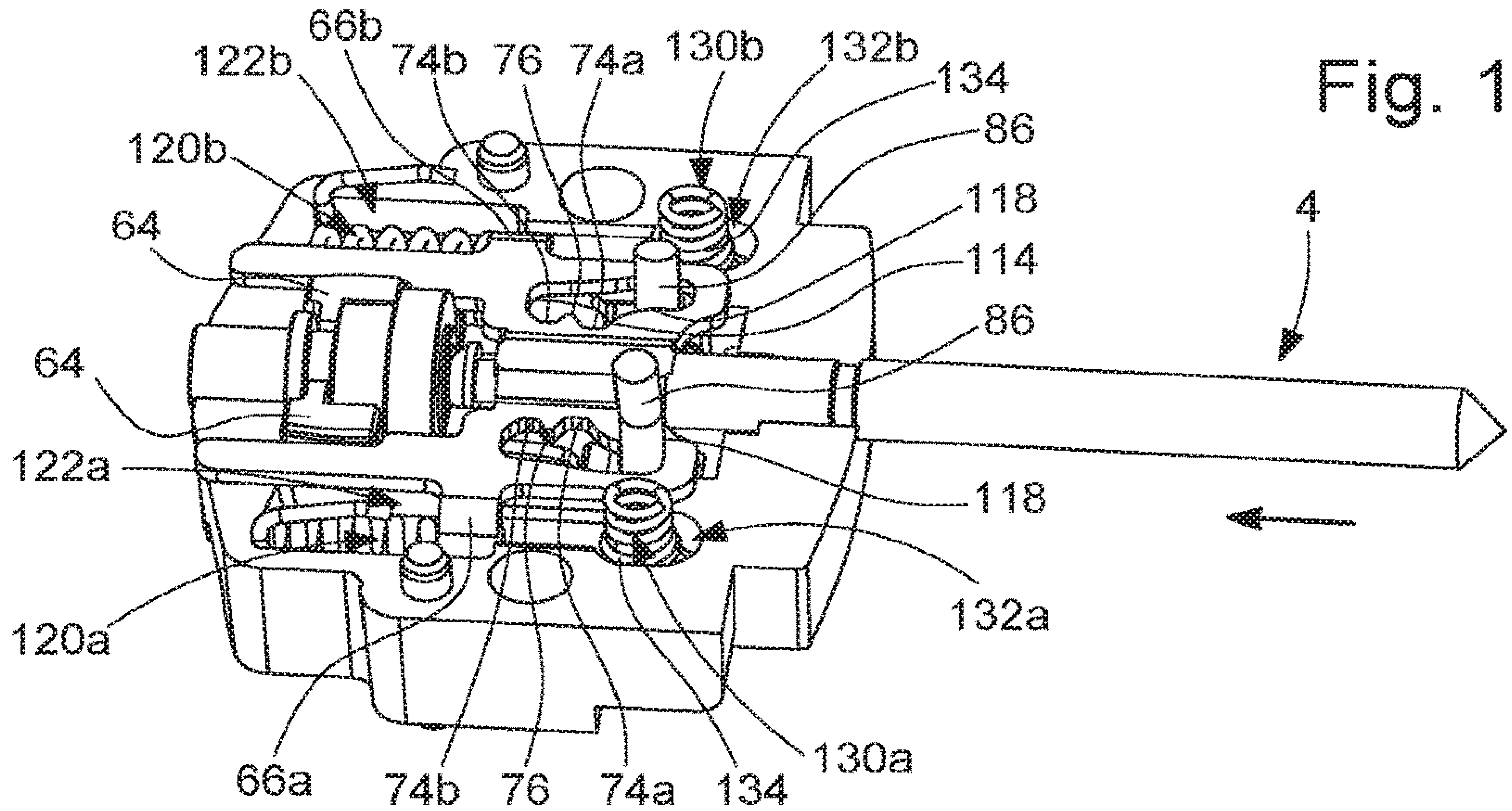


Fig. 12B

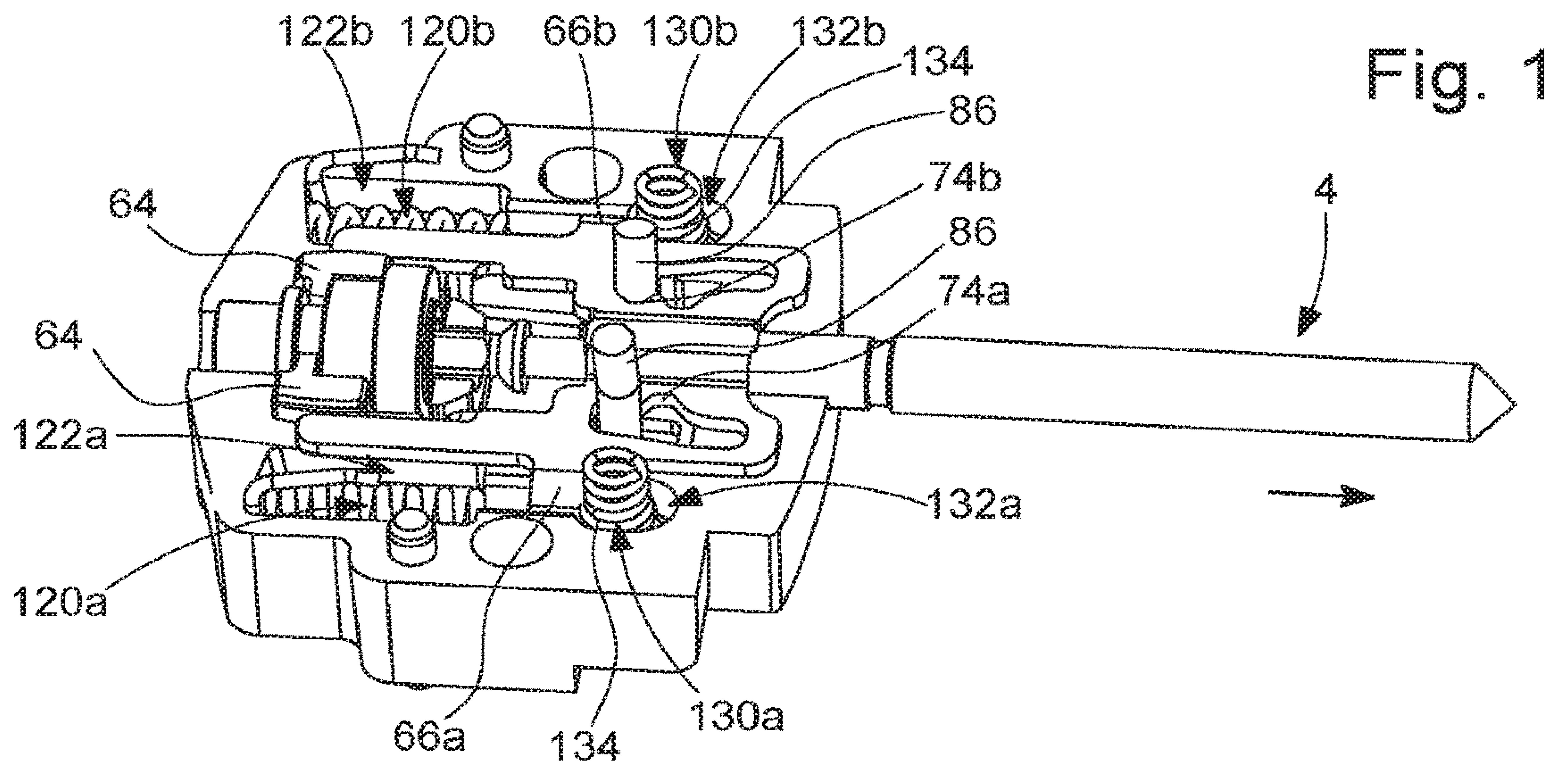


Fig. 12C

Fig. 15

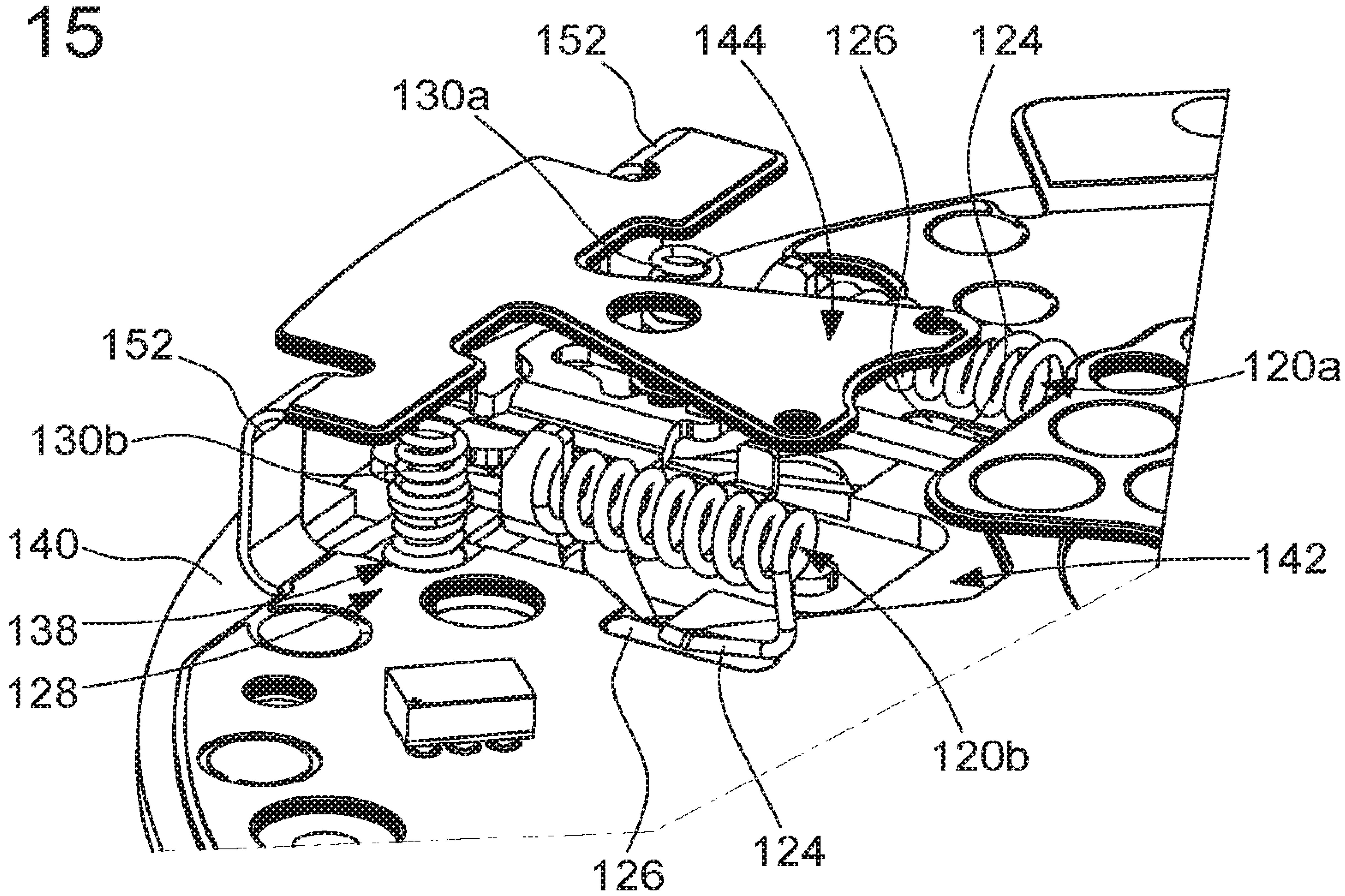

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Fig. 16

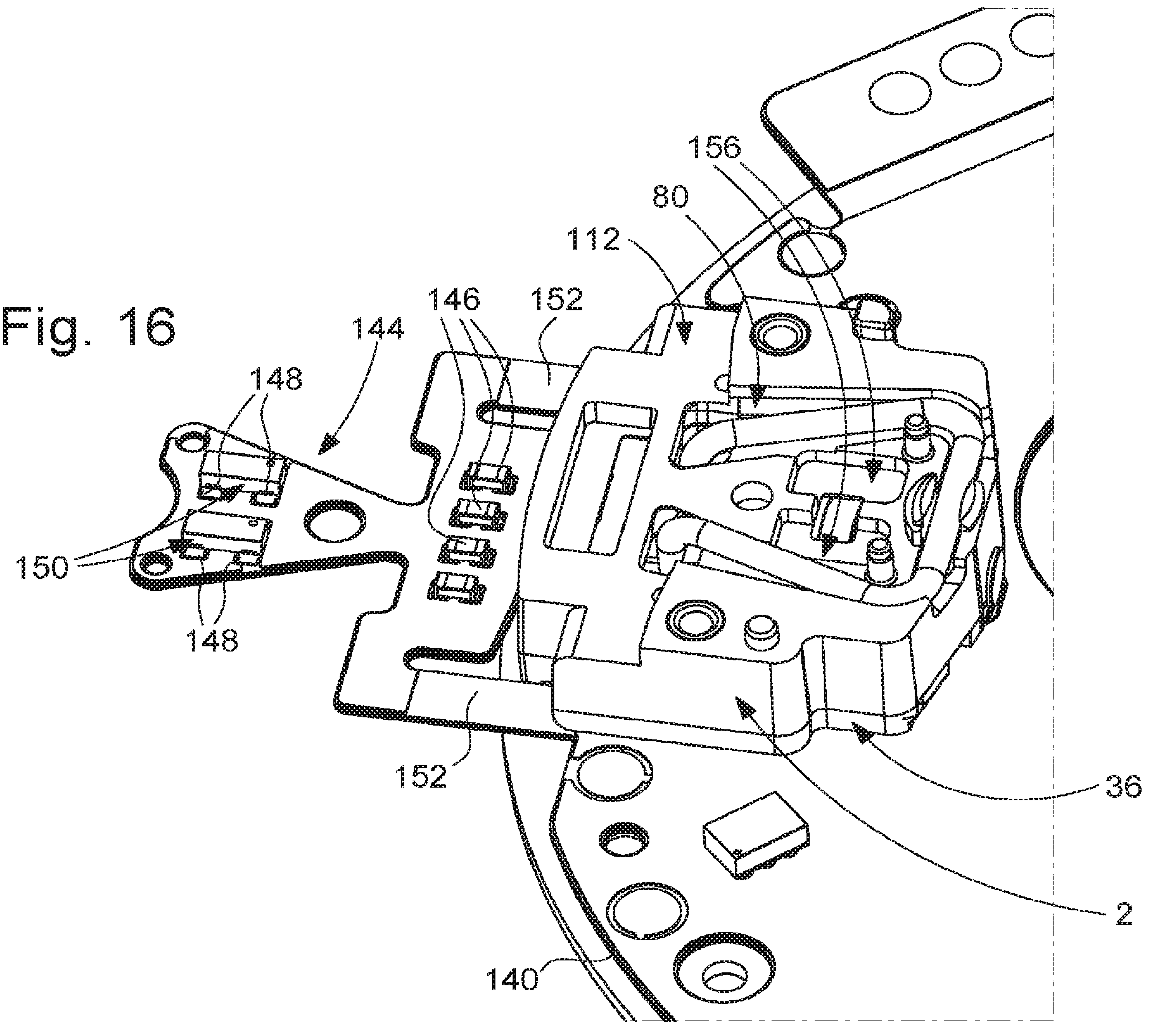
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Fig. 17A

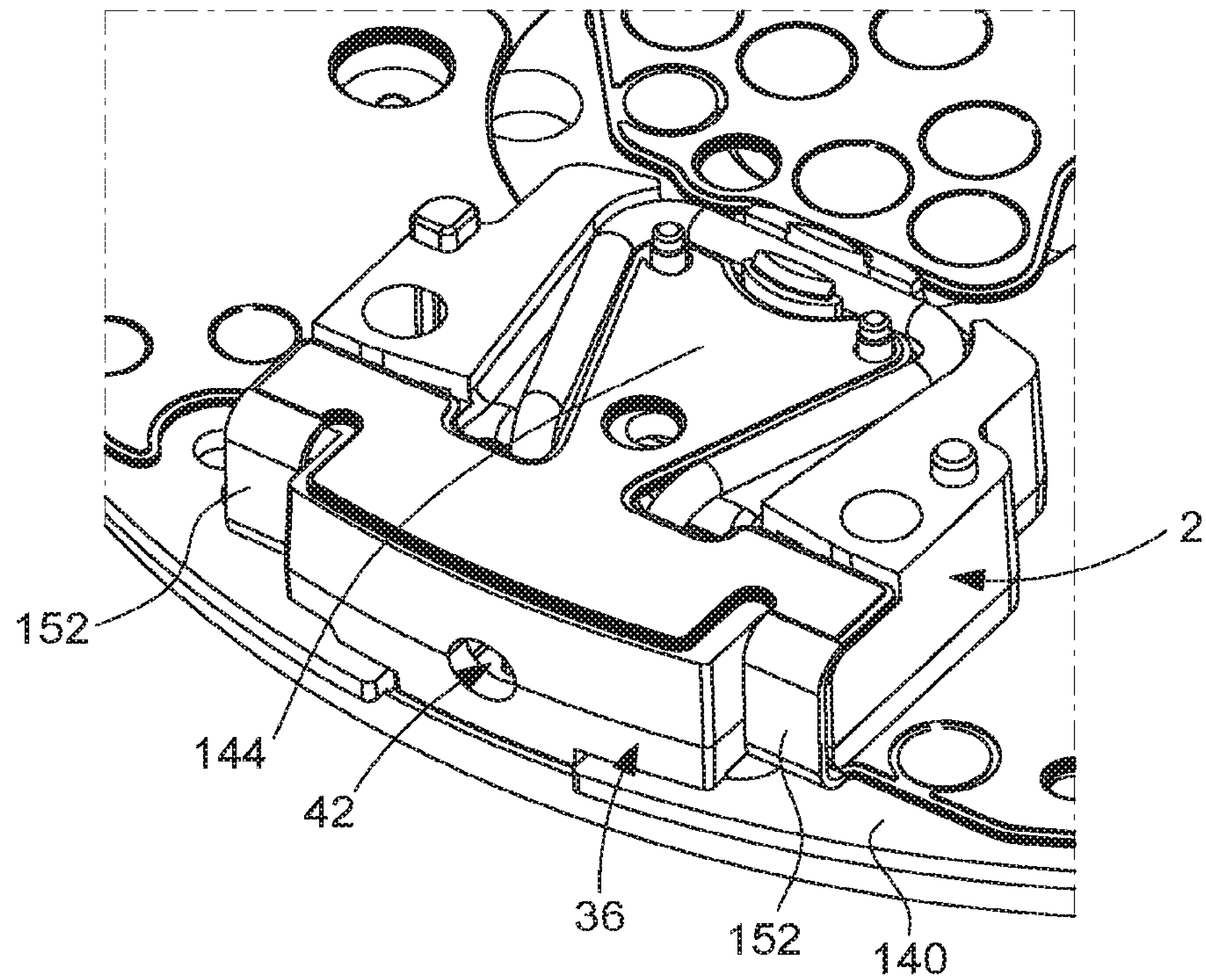

Fig. 17B

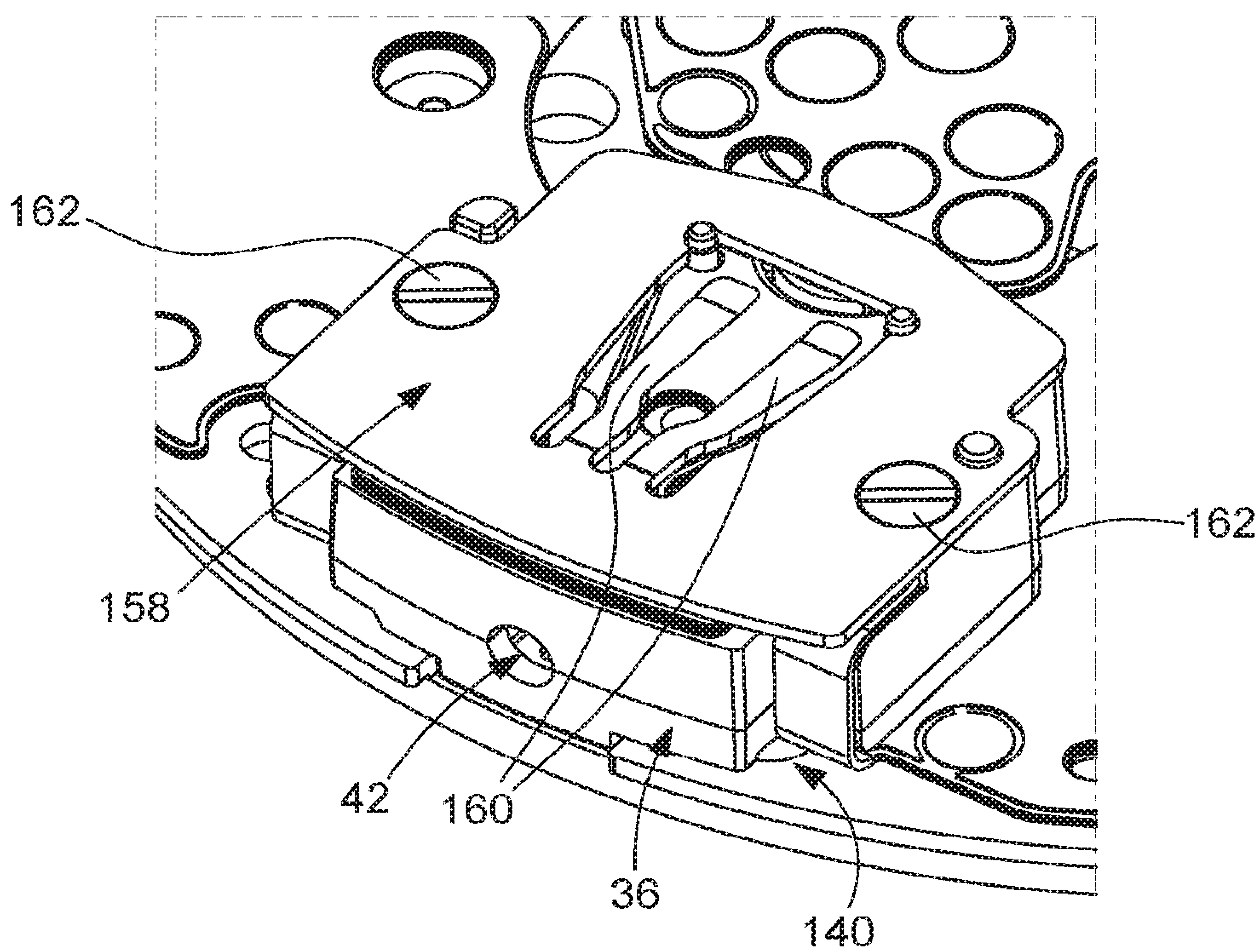

Fig. 18

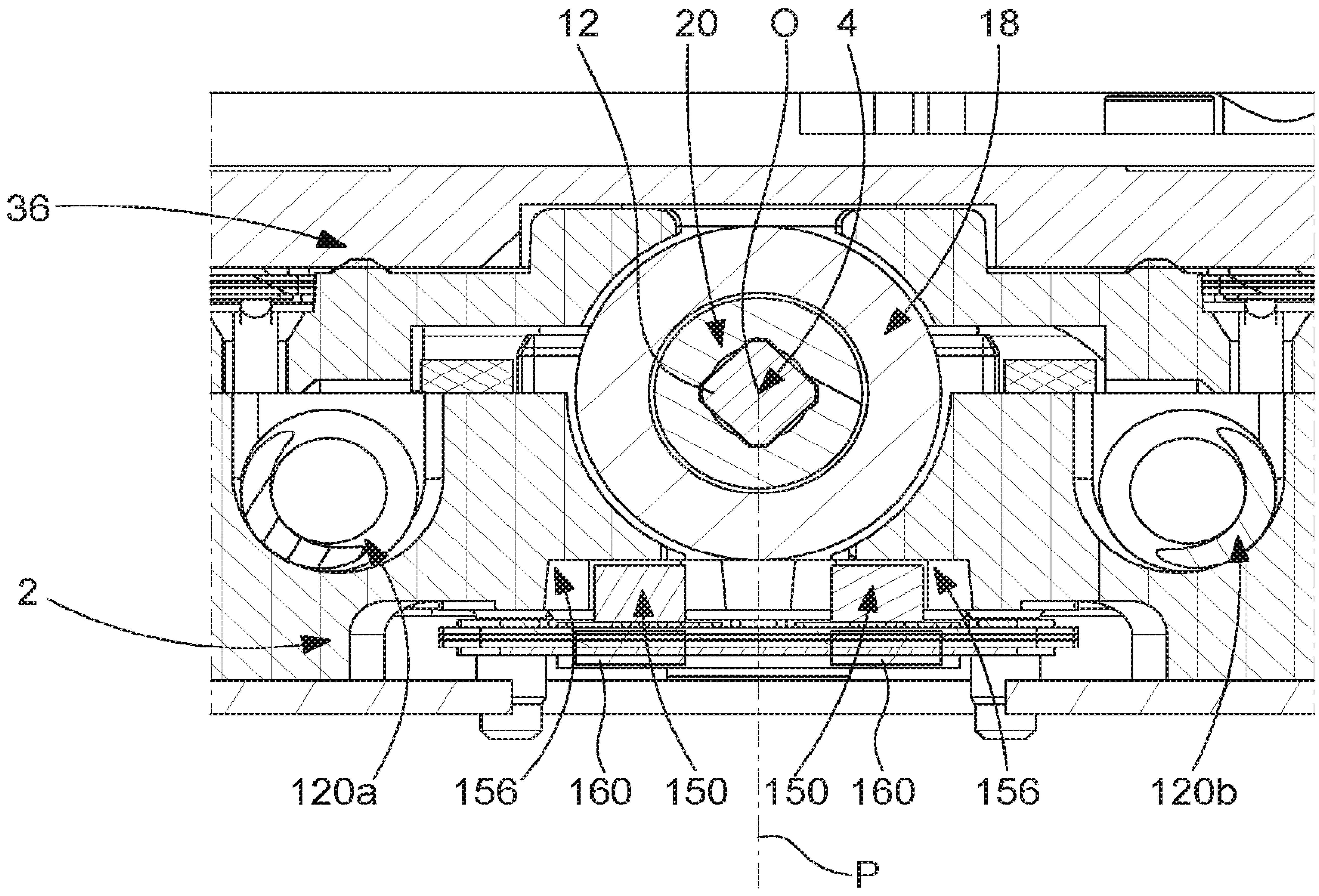
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Fig. 19

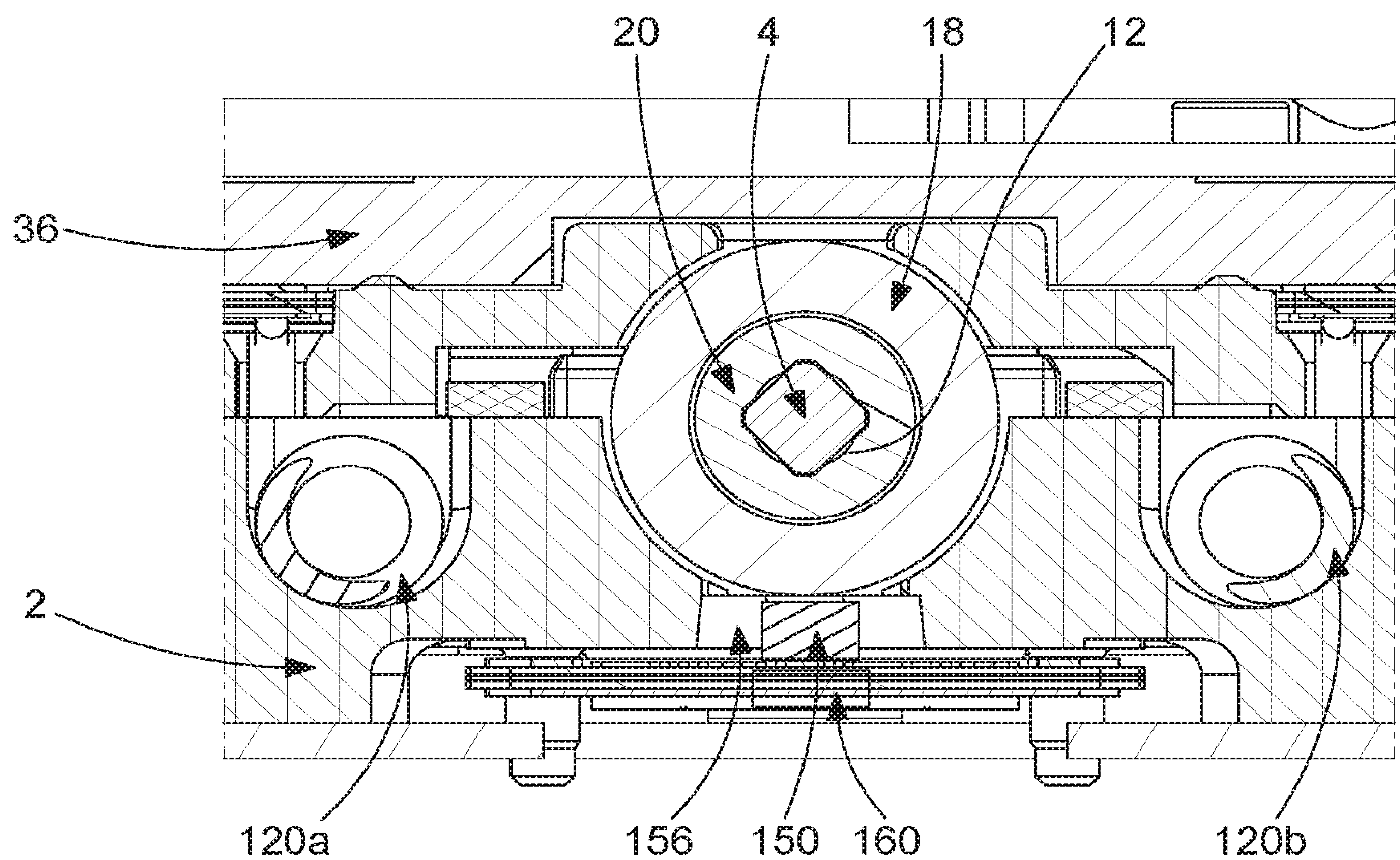
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Fig. 20

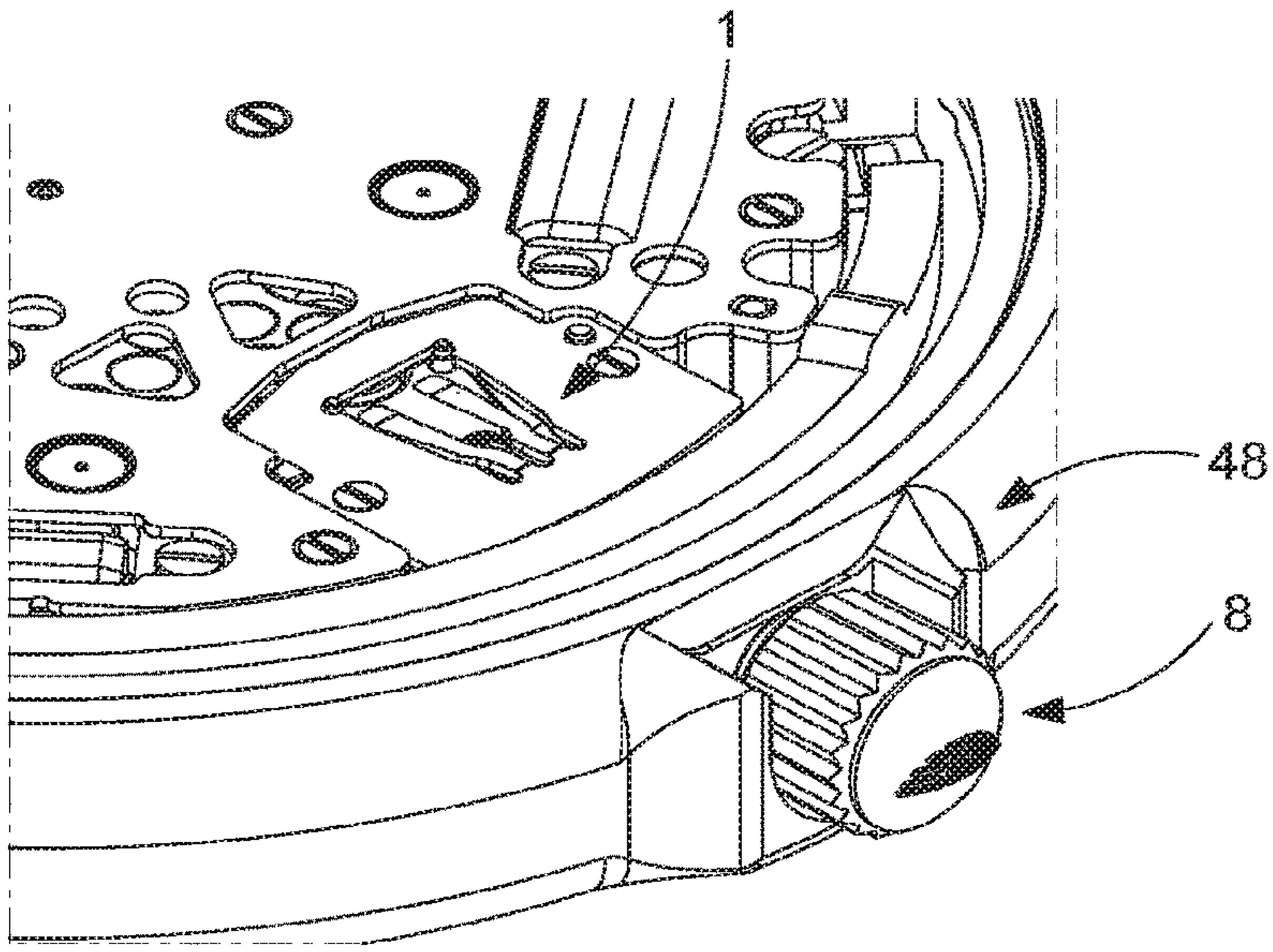


Fig. 21

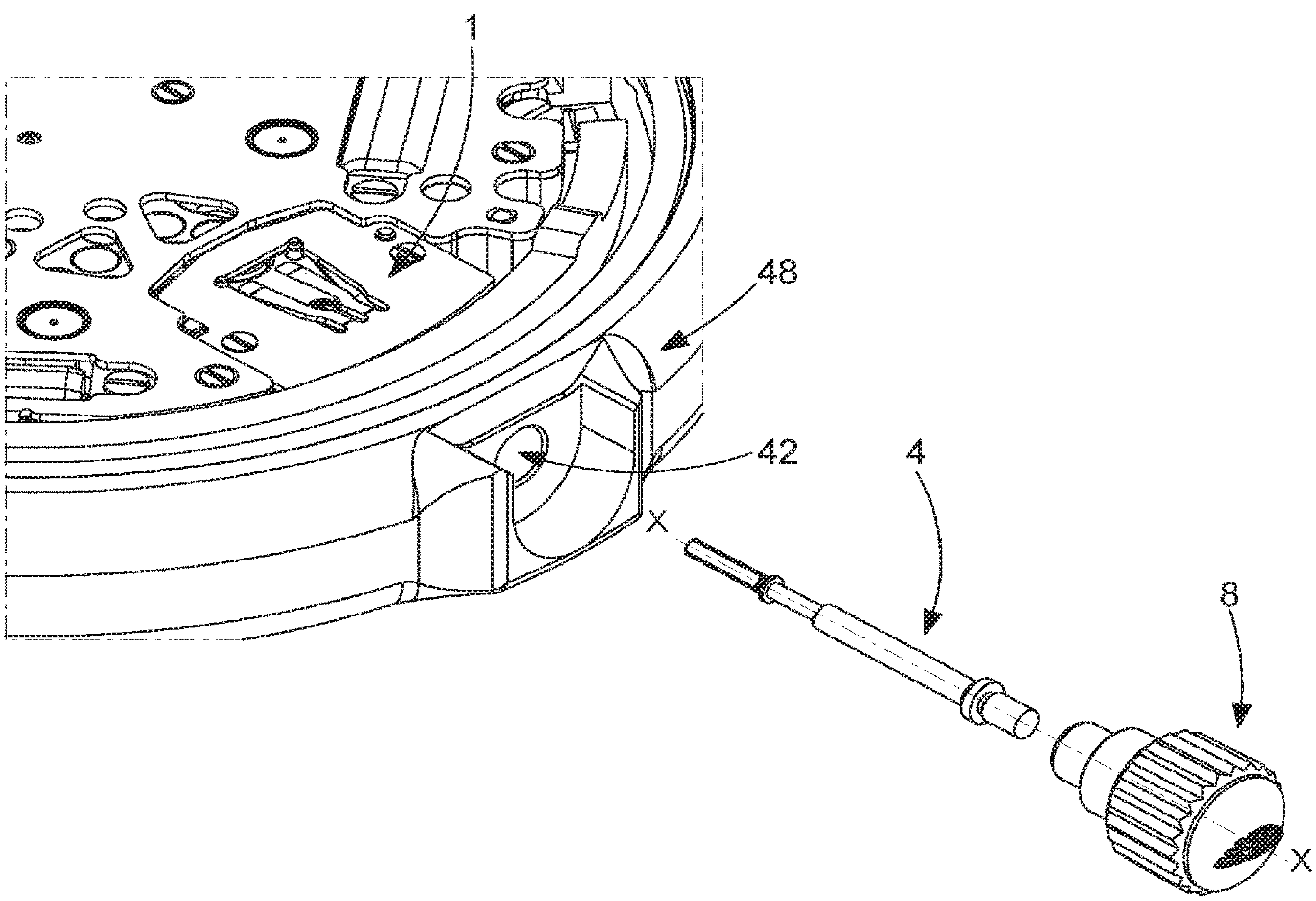
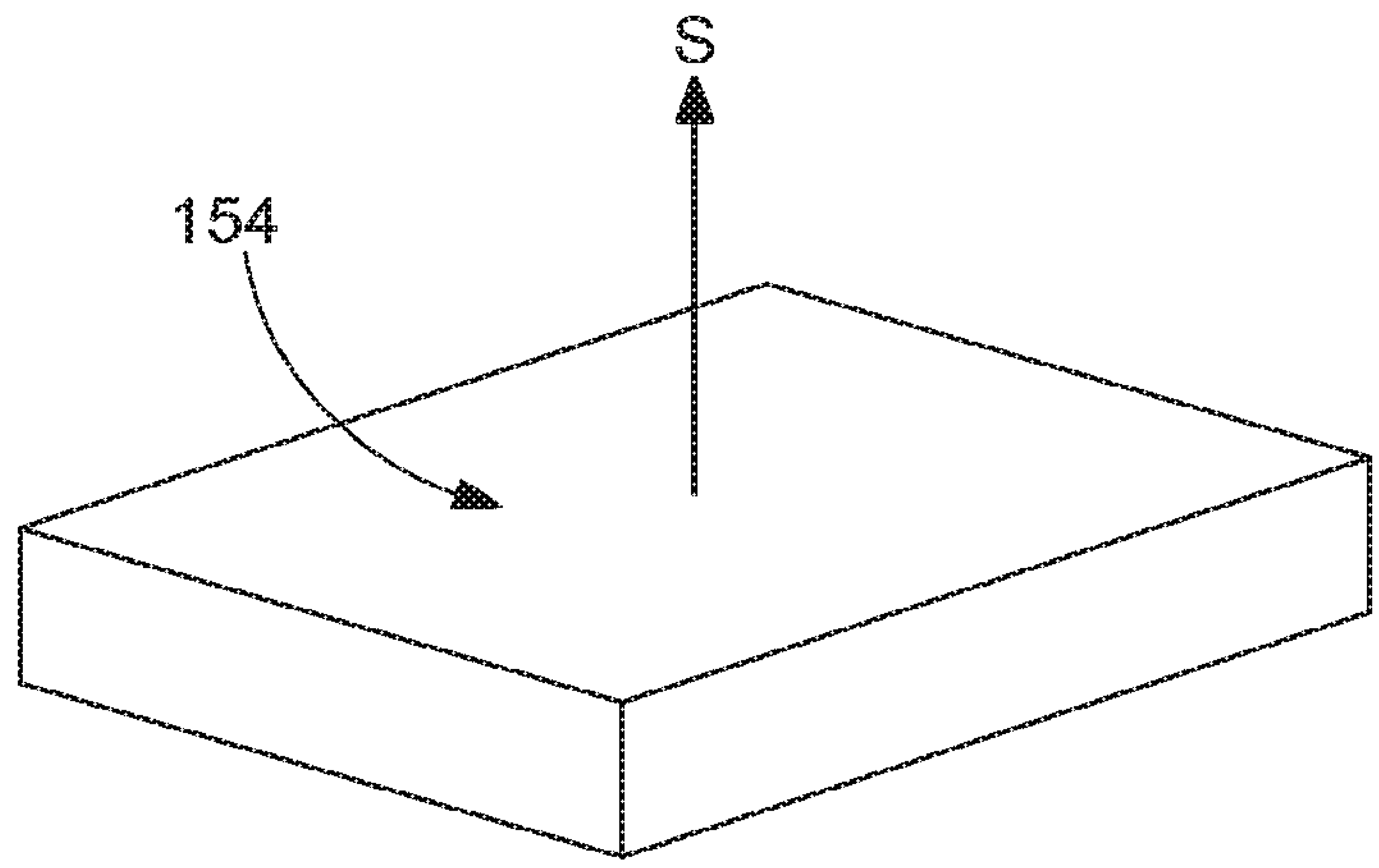


Fig. 22



PORTABLE OBJECT COMPRISING A ROTATING CONTROL STEM WHOSE ACTUATION IS DETECTED BY MEANS OF TWO INDUCTIVE SENSORS

FIELD OF THE INVENTION

The present invention concerns a portable object of small dimensions such as a timepiece, comprising a rotating control stem for controlling at least one electronic or mechanical function of the portable object. More specifically, the invention concerns such a portable object wherein actuation of the rotating control stem is detected by measuring magnetic induction by means of two inductive sensors.

BACKGROUND OF THE INVENTION

The present invention concerns portable objects of small dimensions, such as wristwatches, that comprise a rotating control stem, the actuation of which controls a mechanical or electronic function of the portable object in which the rotating control stem is arranged.

To properly perform the mechanical or electronic function concerned, it must be possible to detect the actuation of the rotating control stem. Among various possible solutions, one consists in measuring the variation in magnetic induction produced by the rotation of a magnet integral with the control stem. To detect this variation in magnetic induction, it is possible to use a magnetic sensor such as a Hall effect sensor which is capable of measuring the value of magnetic induction of the environment in which it is located.

A recurrent problem that arises in the field of detecting the rotation of a control stem by measuring magnetic induction is that of knowing precisely how far and in which direction the control stem is rotated. To overcome this problem, systems have already been proposed that include a pair of magnetic sensors such as magnetoresistors or Hall-effect sensors. In these known systems, the magnetic sensors detect the variation in magnetic induction produced by the rotation of the magnet integral with the control stem in two orthogonal directions in space.

One drawback of such systems lies in the fact that, since the magnetic sensors measure variations in magnetic induction in two orthogonal directions, it is not possible to subtract from the measuring signal produced by the magnetic sensors the effects due to magnetic disturbances outside the portable object when these magnetic disturbances are directed along the axis of measurement of only one of the two magnetic sensors. Indeed, in that case, the other magnetic sensor does not sense the external magnetic disturbance, so the influence of this magnetic disturbance on the two measuring signals is not symmetrical and therefore cannot be eliminated. It is therefore necessary to provide the portable object with an electromagnetic shield, which is particularly cumbersome and costly. Other solutions are known but more particularly intended for measuring the Earth's magnetic field. In such applications, the magnetic sensor or sensors exhibit high sensitivity since the Earth's magnetic field to be measured is very low, typically on the order of 20 to 60 μT. However, these magnetic sensors cannot usually measure magnetic induction in excess of 5 mT, whereas the values associated with magnets of small dimensions frequently reach 100 mT.

SUMMARY OF THE INVENTION

It is an object of the present invention to overcome the aforementioned problems, in addition to others, by providing a portable object comprising a rotating stem for controlling at least one mechanical or electronic function of the portable object, the actuation of the rotating stem being detected in a reliable and reproducible manner by means of inductive sensors.

To this end, the present invention concerns a portable object comprising a control stem, the actuation of which in rotation can control at least one electronic or mechanical function of the portable object, a magnetized ring being driven in rotation by the rotating control stem, the rotation of the control stem and the position of the latter being detected by two inductive sensors arranged to be sensitive to a variation in magnetic induction produced by rotation of the magnetized ring in only two directions in space, which are parallel to each other.

According to other embodiments of the invention which form the subject of the dependent claims:

- the two inductive sensors are arranged at an equal distance from a centre of rotation of the magnetized ring, symmetrically with respect to a plane passing through the centre of rotation of the magnetized ring;
- the two inductive sensors are only sensitive to a variation in magnetic induction in a vertical direction. In other words, the two inductive sensors are sensitive to a variation in magnetic induction in a direction perpendicular to a back of the portable object, the longitudinal axis of symmetry of the control stem extending parallel to said back;
- the two inductive sensors are arranged with respect to the control stem such that, when the magnetized ring rotates as a result of actuation of the control stem, the two inductive sensors produce signals that are phase-shifted with respect to each other by a value comprised between 60° and 120°;
- the portable object includes a frame arranged to serve as a cradle for the control stem, the inductive sensors being disposed inside at least one housing provided in the frame inside which they are held by elastic means;
- the two inductive sensors are disposed inside two distinct housings arranged in the frame;
- the portable object includes a holding plate provided with at least one elastic finger which, by pressure on the inductive sensors, holds the inductive sensors inside the at least one housing in which they are disposed;
- the holding plate is provided with two elastic fingers and the inductive sensors are fixed to a printed circuit sheet on which the elastic fingers press at the locations where the inductive sensors are fixed;
- the printed circuit sheet is flexible and folded down onto the frame so that the inductive sensors are disposed inside the housings;
- the elastic fingers immobilise the inductive sensors in a vertical direction;
- the elastic fingers are arranged to force the inductive sensors against the bottom of the housings inside which they are disposed.

An 'inductive sensor' means a sensor that transforms a magnetic field passing therethrough into electric voltage due to the phenomenon of induction defined by Lenz's law and Faraday's law. By way of example, this may be a Hall effect sensor or a magnetoresistance component of the AMR (anisotropic magnetoresistance), GMR (giant magnetoresistance) or TMR (tunneling magnetoresistance) type.

As a result of these features, the present invention provides a portable object in which detection of the rotation of a control stem controlling at least one mechanical or electronic function of the portable object is obtained by measuring the variation in magnetic induction caused by rotation of a magnet driven by the control stem by means of two inductive sensors. These two inductive sensors are arranged to be sensitive to a variation in magnetic induction in only one direction in space. It is clear that the magnetic induction produced by the environment in which the portable object is located is added to the magnetic induction produced by the magnetized ring. By teaching that the pair of inductive sensors are arranged so that the sensors exhibit sensitivity to magnetic induction in only a single direction, the present invention makes it possible, via a suitable signal processing treatment, to completely eliminate from the measurement result the influence of the magnetic induction of the environment in which the portable object is located. In fact, as a result of these measures, the case where magnetic disturbances produced by the environment in which the portable object is located are directed along the axis of measurement of only one of the two inductive sensors cannot occur. Consequently, the case where one of the two inductive sensors does not sense the external magnetic disturbance is precluded, so that the influence of the external magnetic disturbance on the measurement signals is the same for both inductive sensors and can therefore be eliminated. It is consequently unnecessary to magnetically shield the portable object to avoid the influence of magnetic induction outside the portable object, which saves space. This is very advantageous in the case of a portable object of small dimensions in which the available space is necessarily very limited. The lack of shielding also simplifies the manufacture of the portable object and thus ensures better reliability and a lower cost price.

The invention also concerns a method for detecting a position of a control stem, the actuation of which in rotation controls an electronic or mechanical function of a portable object provided with the control stem, a magnetized ring being driven in rotation by the control stem, the rotation of the control stem and the position of the latter being detected by two inductive sensors arranged to be sensitive to a variation in magnetic induction produced by rotation of the magnetized ring in only one direction in space, the method comprising the step which consists in calculating the arctangent function of the ratio between the signals produced by each of the inductive sensors to determine the direction of rotation and the position of the control stem.

As a result of these features, it is possible, regardless of the direction of rotation of the control stem, to determine the absolute position of the control stem, i.e. it is possible at any time to know the angular position of the stem. The resolution of the position detection measurement of the control stem is thus high and reproducible from one object to another, even in the case of large scale production.

BRIEF DESCRIPTION OF THE DRAWINGS

Other features and advantages of the present invention will appear more clearly from the following detailed description of an example embodiment of a portable object according to the invention, this example being given purely by way of non-limiting illustration with reference to the annexed drawing, in which:

FIG. **1** is a perspective view, in an unassembled state, of a device for controlling at least one electronic function of a portable object of small dimensions.

FIG. **2** is a top, perspective view of the lower frame.

FIG. **3** is a perspective view of the control stem which, from right to left in the Figure, extends from its rear end to its front end.

FIG. **4** is a perspective view, in an unassembled state, of the smooth bearing and of the magnetic assembly formed of a support ring and a magnetized ring.

FIG. **5** is a longitudinal cross-sectional view along a vertical plane of a control device inside which are arranged the smooth bearing and the magnetic assembly formed of the support ring and the magnetized ring.

FIG. **6** is a bottom, perspective view of the upper frame.

FIG. **7**A is a top, perspective view of the plate for indexing the position of the control stem.

FIG. **7**B is a larger scale view of the area encircled in FIG. **7**A.

FIG. **8** is a perspective view of the positioning spring arranged to cooperate with the plate for indexing the position of the control stem.

FIG. **9** is a top, perspective view of the spring for limiting the displacement of the control stem position indexing plate.

FIG. **10** is a perspective view of the disassembly plate.

FIG. **11** is a longitudinal cross-sectional view of one part of the control device showing the hole into which a pointed tool is inserted to release the control stem from the position indexing plate.

FIG. **12**A is a perspective view showing the control stem cooperating with the position indexing plate and the positioning spring, the control stem being in stable position T**1**.

FIG. **12**B is a similar view to that of FIG. **12**A, with the control stem in an unstable pushed-in position T**0**.

FIG. **12**C is a similar view to that of FIG. **12**A, with the control stem in stable pulled-out position T**2**.

FIG. **13** is a perspective view of the first and second contact springs.

FIGS. **14**A and **14**B are schematic views that illustrate the cooperation between the fingers of the control stem position indexing plate and third and fourth contact springs.

FIG. **15** is a partial, perspective view of the flexible printed circuit sheet on which are arranged the contact pads of first and second contact springs.

FIG. **16** is a perspective view of the free portion of the flexible printed circuit sheet on which are fixed the inductive sensors.

FIG. **17**A is a perspective view of the control device, onto a rear face of which is folded the free portion of the flexible printed sheet.

FIG. **17**B is a perspective view of the control device, onto a rear face of which the free portion of the flexible printed circuit sheet is folded and held by means of a holding plate fixed by screws to the control device.

FIG. **18** is an elevation view of the system for detecting the position of the magnetized ring by means of two inductive sensors.

FIG. **19** is an elevation view of the system for detecting rotation of the magnetized ring by means of a single inductive sensor.

FIG. **20** is a perspective view of the control device installed in a portable object.

FIG. **21** is a similar view to that of FIG. **20**, with the control stem removed from the portable object.

FIG. **22** is a schematic, perspective view of the sensing element of an inductive sensor and of the direction in which this element is sensitive to fluctuations in magnetic induction.

DETAILED DESCRIPTION OF ONE EMBODIMENT OF THE INVENTION

The present invention proceeds from the general inventive idea which consists in detecting the rotation of a control stem mounted in a portable object of small dimensions, such as a timepiece, in a reliable and reproducible manner from one portable object to another, particularly in the case of mass production. To overcome this problem, it is proposed to drive a magnetized ring in rotation via the control stem and to detect the variation in magnetic induction caused by rotation of the ring by means of a pair of inductive sensors. These two inductive sensors are arranged to be sensitive each to fluctuations in magnetic induction in only one direction in space. Consequently, the influence of magnetic induction outside the portable object is the same on the measuring signals of both inductive sensors, so that, via a suitable signal processing process, it is possible to completely eliminate from the measurement result the influence of the magnetic induction of the environment in which the portable object is located.

The invention also concerns a method for detecting the position and the direction of rotation of a rotating control stem which consists in calculating the arctangent function of the ratio between the signals produced by two inductive sensors arranged to be sensitive to fluctuations in magnetic induction in two directions in space parallel to each other. Since the magnetic induction of the environment in which the portable object is located only exercises an influence on the sensing elements of the two inductive sensors in one direction in space, calculating the arctangent function of the ratio between the signals produced by these two inductive sensors can eliminate the signal component due to the influence of magnetic induction outside the portable object.

In all that follows, the back-to-front direction is a rectilinear direction which extends horizontally along longitudinal axis of symmetry X-X of the control stem from the external actuation crown towards the interior of the portable object equipped with the control device, parallel to a plane in which a back of the portable object extends. Thus, the control stem will be pushed from back to front, and will be pulled from front to back. Further, the vertical direction is a direction that extends perpendicularly to the plane in which the control stem extends.

FIG. **1** is a perspective view, in an unassembled state, of a device for controlling at least one electronic function of a portable object of small dimensions, such as a wristwatch. Designated as a whole by the general reference number **1**, this control device includes a lower frame **2**, for example made of an injected plastic material or of a non-magnetic metallic material such as brass, and serves as a cradle for a control stem **4**, preferably of elongated and substantially cylindrical shape, provided with a longitudinal axis of symmetry X-X. This control stem **4** is arranged to slide from front to back and from back to front along its longitudinal axis of symmetry X-X and/or to rotate about said same axis of longitudinal symmetry X-X in the clockwise and anticlockwise direction.

At a rear end **6**, which will be located outside the portable object once the latter is equipped with a control device **1**, control stem **4** will receive an actuation crown **8** (see FIG. **20**).

At a front end **10**, which will be located inside control device **1** once the latter is assembled, control stem **4** has, for example, a square section **12** and receives in succession a magnetic assembly **14** and a smooth bearing **16**.

Magnetic assembly **14** includes a magnetized ring **18** and a support ring **20**, on which magnetized ring **18** is fixed, typically by adhesive bonding (see FIG. **4**). Support ring **20** is a component of generally cylindrical shape. As seen in FIG. **5**, support ring **20** has, from back to front, a first section **22*a*** having a first external diameter D**1** on which is engaged magnetized ring **18**, and a second section **22*b*** having a second external diameter D**2** greater than first external diameter D**1** and which delimits a shoulder **24** against which magnetized ring **18** abuts. The first section **22*a*** of support ring **20** is pierced with a square hole **26** which is adapted in shape and size to square section **12** of control stem **4** and forms with control stem **4** a sliding pinion type system. In other words, support ring **20** and magnetized ring **18** remain immobile when control stem **4** is made to slide axially. However, control stem **4** drives support ring **20** and magnetized ring **18** in rotation when control stem **4** is rotated. It is clear from the foregoing that magnetized ring **18**, carried by support ring **20**, is not in contact with control stem **4** which makes it possible to protect it in the event of shocks applied to the portable object equipped with a control device **1**.

Smooth bearing **16** defines (see FIG. **5**) a cylindrical housing **28** whose first internal diameter D**3** is very slightly greater than the diameter of the circle in which is inscribed square section **12** of control stem **4**, to allow control stem **4** to slide axially and/or to rotate inside this cylindrical housing **28**. Smooth bearing **16** thus ensures perfect axial guiding of control stem **4**.

It is noted that the square hole **26** provided in first section **22*a*** of support ring **20** is extended towards the front of control device **1** by an annular hole **30** whose second internal diameter D**4** is fitted onto third external diameter D**5** of smooth bearing **16**. Support ring **20** is thus fitted for free rotation on smooth bearing **16** and moves into axial abutment against smooth bearing **16**, which ensures the perfect axial alignment of these two components and makes it possible to correct any problems of concentricity that may be caused by a sliding pinion type coupling.

It is observed that, for axial immobilization thereof, smooth bearing **16** is provided on its outer surface with a circular collar **32** which projects into a first groove **34*a*** and into a second groove **34*b***, respectively arranged in lower frame **2** (see FIG. **2**) and in an upper frame **36** (see FIG. **6**), arranged to cover lower frame **2** and, for example, made of an injected plastic material or of a non-magnetic material, such as brass. These two lower and upper frames **2** and **36** will be described in detail below.

It is important to note that the magnetic assembly **14** and smooth bearing **16** described above are indicated purely for illustrative purposes. Indeed, smooth bearing **16**, for example made of steel or brass, is arranged to prevent control stem **4**, for example made of steel, rubbing against lower and upper frames **2** and **36**, and causing wear of the plastic material of which these two lower and upper frames **2** and **36** are typically made. However, in a simplified embodiment, it is possible to envisage not using such a smooth bearing **16** and arranging for control stem **4** to be directly carried by lower frame **2**.

Likewise, magnetized ring **18**, and support ring **20** on which magnetized ring **18** is fixed, are intended for the case where rotation of control stem **4** is detected by a local variation in the magnetic field induced by the pivoting of magnetized ring **18**. It is, however, entirely possible to envisage replacing magnetic assembly **14**, for example with a sliding pinion which, according to its position, will for example control the winding of a mainspring or the time-setting of a watch equipped with control device **1**.

It is also important to note that the example of control stem **4** provided on one part of its length with a square section is given purely for illustrative purposes. Indeed, in order to drive magnetic assembly **14** in rotation, control stem

4 may have any type of section other than a circular section, for example triangular or oval.

Lower frame **2** and upper frame **36**, the combined assembly of which defines the external geometry of control device **1** are, for example, of generally parallelepiped shape. Lower frame **2** forms a cradle which receives control stem **4**. To this end (see FIG. **2**), lower frame **2** includes, towards the front, a first receiving surface **38** of semicircular profile, which serves as a seat for smooth bearing **16** and in which is provided the first groove **34***a* which receives circular collar **32**. Both axial and rotational immobilization of smooth bearing **1** are thus ensured.

Lower frame **2** further includes, towards the back, a second receiving surface **40**, whose semicircular profile is centred on longitudinal axis of symmetry X-X of control stem **4**, but whose diameter is greater than that of control stem **4**. It is important to understand that control stem **4** only rests on second receiving surface **40** at the stage when the assembled control device **1** is tested prior to being integrated in the portable object. At this assembly stage, control stem **4** is inserted into control device **1** for test purposes and extends horizontally, supported and axially guided by smooth bearing **16** at its front end **10** and via second receiving surface **40** at its rear end **6**. However, once control device **1** is integrated in the portable object, control stem **4** passes through a hole **42** provided in case middle **48** of the portable object in which it is guided and supported (see FIG. **21**) and which is delimited downwardly by a back **49**.

Third and fourth clearance surfaces **44***a* and **46***a* of semicircular profile are also provided in lower frame **2** and complementary clearance surfaces **44***b* and **46***b* (see FIG. **6**) are provided in upper frame **36** for receiving magnetic assembly **14**, formed of magnetized ring **18** and of its support ring **20**. It will be noted that magnetized ring **18** and its support ring **20** are not in contact with third and fourth clearance surfaces **44***a* and **46***a* and complementary clearance surfaces **44***b* and **46***b* when control device **1** is assembled and mounted in the portable object. It is also noted that third clearance surface **44***a* and its corresponding complementary clearance surface **44***b* are delimited by an annular collar **50** for axially locking magnetic assembly **14**.

As visible in FIG. **3**, behind square section **12**, control stem **4** has a cylindrical section **52** whose diameter is comprised between the diameter of the circle in which is inscribed square section **12** of control stem **4** and the POT text as filed primitive diameter of a rear section **54** of said control stem **4**, at the end of which is fixed actuation crown **8**. This cylindrical section **52** of reduced diameter forms a groove **56** inside which is placed a position indexing plate **58** for control stem **4** (see FIG. 7A). To this end, position indexing plate **58** has a curved portion **60** which follows the profile of reduced diameter cylindrical section **52**. Position indexing plate **58** may be, for example, obtained by stamping a thin, electrically conductive metal sheet. However, it is also possible to envisage making position indexing plate **58**, for example, by moulding a hard plastic material loaded with conductive particles. The engagement of position indexing plate **58** in groove **56** ensures the coupling in translation, from front to back and from back to front, between control stem **4** and position indexing plate **58**. However, as will become clearer below, position indexing plate **58** is free with respect to control stem **4** in a vertical direction z perpendicular to the longitudinal axis of symmetry X-X of control stem **4**.

As visible in FIG. **7**A, position indexing plate **58** is a substantially flat and generally U-shaped part. This position indexing plate **58** includes two substantially rectilinear guide arms **62** which extend parallel to each other and which are connected to each other by curved portion **60**. These two guide arms **62** are axially guided, for example, against two studs **64** arranged in lower frame **2** (see in particular FIG. **2**). Guided by its two guide arms **62**, position indexing plate **58** slides along a rim **68** arranged in upper frame **36** and whose perimeter corresponds to that of position indexing plate **58** (see FIG. **6**). Position indexing plate **58** also includes two fingers **66***a*, **66***b* which extend vertically downwards on either side of the two guide arms **62**. In sliding along rim **68**, position indexing plate **58** has the function of ensuring the translational guiding of control stem **4** from front to back and from back to front. Fingers **66***a*, **66***b*, are intended, in particular, to prevent position indexing plate **58** from bracing when the latter moves in translation.

Two apertures **70** exhibiting an approximately rectangular contour are provided in guide arms **62** of position indexing plate **58** (see in particular FIG. 7B). These two apertures **70** extend symmetrically on either side of longitudinal axis of symmetry X-X of control stem **4**. The sides of the two apertures **70** closest to longitudinal axis of symmetry X-X of control stem **4** have a cam path **72** of substantially sinusoidal shape, formed of a first and a second recess **74***a*, **74***b* separated by a peak **76**.

The two apertures **70** provided in guide arms **62** are intended to receive the two ends **78** of a positioning spring **80** (see FIG. **8**). This positioning spring **80** is generally U-shaped with two arbors **82** which extend in a horizontal plane and which are connected to each other by a base **84**. At their free end, the two arbors **82** are extended by two substantially rectilinear arms **86** which stand upright. Positioning spring **80** is intended to be mounted in control device **1** through the bottom of lower frame **2**, so that ends **78** of arms **86** project into apertures **70** of position indexing plate **58**. It will be seen below that the cooperation between position indexing plate **58** and positioning spring **80** makes it possible to index the position of control stem **4** between an unstable pushed-in position T**0** and two stable positions T**1** and T**2**.

It was mentioned above that position indexing plate **58** is coupled in translation to control stem **4**, but that it is free with respect to control stem **4** in the vertical direction z. It is thus necessary to take steps to prevent position indexing plate **58** disengaging from control stem **4** in normal conditions of use, for example under the effect of gravity. To this end (see FIGS. **9** and **11**), a spring **88** for limiting the displacement of position indexing plate **58** in vertical direction z is placed above and at a short distance from position indexing plate **58**. Displacement limiting spring **88** is captive between lower frame **2** and upper frame **36** of control device **1**, but is not, in normal conditions of use, in contact with position indexing plate **58**, which prevents parasitic friction forces being exerted on control stem **4**, which would make the latter difficult to operate and cause problems of wear. Displacement limiting spring **88** is, however, sufficiently close to position indexing plate **58** to prevent the latter being inadvertently uncoupled from control stem **4**.

Displacement limiting spring **88** includes a substantially rectilinear central portion **90** from the ends of which extend two pairs of elastic arms **92** and **94**. These elastic arms **92** and **94** extend on either side of central portion **90** of displacement limiting spring **88**, upwardly away from the horizontal plane in which central portion **90** extends. As these elastic arms **92** and **94** are compressed when upper frame **36** is joined to lower frame **2**, they impart elasticity to displacement limiting spring **88** along vertical direction z. Between the pairs of elastic arms **92** and **94** there is also provided one pair, and preferably two pairs, of stiff lugs **96** which extend perpendicularly downwards on either side of central portion **90** of displacement limiting spring **88**. These stiff lugs **96** which move into abutment on lower frame **2** when upper frame **36** is placed on lower frame **2**, ensure that a minimum space is provided between position indexing plate **58** and displacement limiting spring **88** in normal operating conditions of control device **1**.

Displacement limiting spring **88** guarantees the dismantability of control device **1**. Indeed, in the absence of displacement limiting spring **88**, position indexing plate **58** would have to be integral with control stem **4** and, consequently, control stem **4** could no longer be dismantled. If control stem **4** cannot be dismantled, the movement of the timepiece equipped with control device **1** cannot be dismantled either, which is inconceivable, particularly in the case of an expensive timepiece. Thus, when control device **1**, formed by joining lower and upper frames **2** and **36**, is mounted inside the portable object and control stem **4** is inserted into control device **1** from outside the portable object, control stem **4** slightly lifts position indexing plate **58** against the elastic force of displacement limiting spring **88**. If control stem **4** continues to be pushed forwards, there comes a moment when position indexing plate **58** drops into groove **56** under the effect of gravity. Control stem **4** and position indexing plate **58** are then coupled in translation.

A disassembly plate **98** is provided to allow disassembly of control stem **4** (see FIG. **10**). This disassembly plate **98** is generally H-shaped and includes a straight segment **100** which extends parallel to longitudinal axis of symmetry X-X of control stem **4** and to which a first and a second transverse piece **102** and **104** are attached. The first transverse piece **102** is also provided at its two free ends with two lugs **106** folded up substantially at right angles. Disassembly plate **98** is received inside a housing **108** provided in lower frame **2** and located underneath control stem **4**. This housing **108** communicates with the outside of control device **1** via a hole **110** which opens into a lower face **112** of control device **1** (see FIG. **11**). By inserting a pointed tool into hole **110**, a thrust force can be exerted on disassembly plate **98** which, via its two lugs **106**, in turn pushes position indexing plate **58** against the elastic force of displacement limiting spring **88**. Position indexing plate **58** then leaves groove **56** provided in control stem **4** and exerting a slight backward traction on control stem **4** is sufficient to remove the latter from control device **1**.

From its stable rest position T**1**, control stem **4** can be pushed forwards into an unstable position T**0** or pulled out into a stable position T**2**. These three positions T**0**, T**1** and T**2** of control stem **4** are indexed by cooperation between position indexing plate **58** and positioning spring **80**. More precisely (see FIG. **12**A), the stable rest position T**1**, in which no commands can be entered into the portable object equipped with control device **1**, corresponds to the position in which ends **78** of arms **86** of positioning spring **80** project into first recesses **74***a* of the two apertures **70** provided in guide arms **62** of position indexing plate **58**. From this stable rest position T**1**, control stem **4** can be pushed forwards into an unstable position T**0** (see FIG. **12**B). During this displacement, ends **78** of arms **86** of positioning spring **80** leave first recesses **74***a* and follow a first ramp profile **114** which gradually moves away from longitudinal axis of symmetry X-X of control stem **4** on a first steep slope α (see FIG. **7**B). To force ends **78** of arms **86** of positioning spring **80** to leave first recesses **74***a* and to engage on first ramp profile **114** by moving away from each other, the user must therefore overcome a significant resistance force.

When they reach a transition point **116**, ends **78** of arms **86** engage on a second ramp profile **118** which extends first ramp profile **114** with a second slope β lower than first slope α of first ramp profile **114**. At the instant that ends **78** of arms **86** of positioning spring **80** cross transition point **116** and engage on second ramp profile **118**, the force required from the user to continue moving control stem **4** drops sharply and the user feels a click indicating the transition of control stem **4** between position T**1** and position T**0**. As they follow second ramp profile **118**, arms **86** of positioning spring **80** continue to move slightly away from their rest position and tend to try to move towards each other again under the effect of their elastic return force opposing the thrust force exerted by the user on control stem **4**. As soon as the user releases pressure on control stem **4**, arms **86** of positioning spring **80** will spontaneously return down first ramp profile **114** and their ends **78** will again lodge inside first recesses **74***a* of the two apertures **70** provided in guide arms **62** of position indexing plate **58**. Control stem **4** is thus automatically returned from its unstable position T**0** to its first stable position T**1**.

First and second contact springs **120***a* and **120***b* are arranged compressed inside a first and a second cavity **122***a* and **122***b* provided in lower frame **2**. These first and second contact springs **120***a* and **120***b* could be helical contact springs, strip-springs or other springs. The two cavities **122***a*, **122***b* preferably, but not necessarily, extend horizontally. Because the two contact springs **120***a*, **120***b* are installed in the compressed state, their positioning precision is dependent on the manufacturing tolerance of lower frame **2**. The manufacturing precision of lower frame **2** is higher than the manufacturing precision of these first and second contact springs **120***a*, **120***b*. Consequently, the precision with which position T**0** of control stem **4** is detected is high.

As visible in FIGS. **13** and **15**, one of the ends of first and second contact springs **120***a*, **120***b* is bent to form two contact lugs **124** which will move into abutment on two corresponding first contact pads **126** provided at the surface of a flexible printed circuit sheet **128**. The moment that ends **78** of arms **86** of positioning spring **80** engage on second ramp profile **118** of the two apertures **70** provided in position indexing plate **58** coincides with the moment that fingers **66***a*, **66***b* of position indexing plate **58** come into contact with first and second contact springs **120***a*, **120***b*. Since this position indexing plate **58** is electrically conductive, when fingers **66***a*, **66***b* come into contact with first and second contact springs **120***a*, **120***b*, the electric current passes through position indexing plate **58** and closure of the electrical contact between first and second contact springs **120***a*, **120***b* is detected.

First and second contact springs **120***a*, **120***b* are of the same length. However, preferably, first cavity **122***a* will be, for example, longer than second cavity **122***b*, in particular to take account of tolerance problems (the difference in length between the two cavities **122***a*, **122***b* is several tenths of a millimetre). Thus, when control stem **4** is pushed forwards into position T**0**, finger **66***a* of position indexing plate **58**, which is lined up with first contact spring **120***a* housed inside the first, longest cavity **122***a*, will come into contact with and start to compress first contact spring **120***a*. Control stem **4** will continue to move forward and second finger **66***b* of position indexing plate **58** will come into contact with second contact spring **120***b* housed inside the second, shortest cavity **122***b*. At that moment, position indexing plate **58** will be in contact with first and second contact springs **120***a*, **120***b* and the electric current will flow through position indexing plate **58**, which allows the closure of the electrical contact between the first two contact springs **120***a*, **120***b* to be detected. It is noted that fingers **66***a*, **66***b* of position indexing plate **58** move into abutment contact with first and second contact springs **120***a*, **120***b*. There is thus no friction or wear when control stem **4** is pushed forwards into position T**0** and closes the circuit between first and second contact springs **120***a*, **120***b*. It is also noted that, the difference in length of first and second cavities **122***a* and **122***b* ensures that closure of the electrical contact and entry of the corresponding command into the portable object equipped with control device **1** occur only after a click is felt.

When the two fingers **66***a*, **66***b* of position indexing plate **58** are in contact with first and second contact springs **120***a*, **120***b*, first contact spring **120***a* housed inside first, longest cavity **122***a* is in a compressed state. Consequently, when the user releases pressure on control stem **4**, this first contact spring **120***a* relaxes and forces control stem **4** to return from its unstable pushed-in position T**0** to its first stable position T**1**. The first and second contact springs **120***a*, **120***b* thus act simultaneously as electrical contact parts and elastic return means for control stem **4** in its first stable position T**1**.

From first stable position T**1**, it is possible to pull control stem **4** backwards into a second stable position T**2** (see FIG. **12**C). During this movement, ends **78** of arms **86** of positioning spring **80** will elastically deform to pass from first recesses **74***a* to second recesses **74***b*, crossing peaks **76** of the two apertures **70** provided in guide arms **62** of position indexing plate **58**. When control stem **4** reaches its second stable position T**2**, the two fingers **66***a*, **66***b* of position indexing plate **58** move into abutment against third and fourth contact springs **130***a* **130***b* (see FIG. **13**), which are housed inside third and fourth cavities **132***a*, **132***b* provided in lower frame **2**. These third and fourth contact springs **130***a*, **130***b* could be helical contact springs, strip-springs or other springs. Third and fourth cavities **132***a*, **132***b* preferably extend vertically for reasons of space in control device **1**. Since position indexing plate **58** is electrically conductive, when fingers **66***a*, **66***b* come into contact with third and fourth contact springs **130***a*, **130***b*, the electric current flows through position indexing plate **58** and closure of electrical contact T**2** between these contact springs **130***a*, **130***b* is detected.

It will be noted that, in the case of stable position T**2**, fingers **66***a*, **66***b* of position indexing plate **58** also come into abutment contact with third and fourth contact springs **130***a*, **130***b*, thereby avoiding any risk of wear from friction. Further, third and fourth contact springs **130***a*, **130***b* are capable of bending when fingers **66***a*, **66***b* of position indexing plate **58** collide therewith, and therefore of absorbing any lack of precision in the positioning of position indexing plate **58**.

Preferably, but not necessarily, third and fourth contact springs **130***a*, **130***b* are arranged to work in flexion (see FIGS. **14**A and **14**B). Indeed, with contact springs **130***a*, **130***b* whose diameter is constant, fingers **66***a*, **66***b* of position indexing plate **58** come into contact with contact springs **130***a*, **130***b* over a large surface close to their points of attachment in lower frame **2** and upper frame **36**. The proximity of the contact surface to the attachment points of contact springs **130***a*, **130***b* induces shearing stresses in contact springs **130***a*, **130***b* which may lead to premature wear and breakage of the latter. To overcome this problem, contact springs **130***a*, **130***b* have, preferably substantially at mid-height, an increase in diameter **134** which comes into contact with fingers **66***a*, **66***b* of position indexing plate **58** when control stem **4** is pulled into its stable position T**2**. At their upper end, third and fourth contact springs **130***a*, **130***b* are guided in two holes **136** provided in upper frame **36** and come into contact with second contact pads **138** provided at the surface of flexible printed circuit sheet **128**. It is clear that, when control stem **4** is pulled backwards into its stable position T**2**, fingers **66***a*, **66***b* of positioning indexing plate **58** come into contact on a reduced surface with third and fourth contact springs **130***a* and **130***b* at their largest diameter **134**, which allows contact springs **130***a*, **130***b* to bend between their two points of attachment in lower frame **2** and upper frame **36**.

In FIG. **15**, lower and upper frames **2** and **36** have been deliberately omitted to facilitate understanding of the drawing. As represented in FIG. **15**, flexible printed circuit sheet **128** is fixed on a plate **140** located on the dial side of the portable object. It takes the form, in particular, of a cutout **142** adapted in shape and size to receive upper frame **36**. One portion **144** of flexible printed circuit sheet **128** remains free (see FIG. **16**). This free portion **144** of flexible printed circuit sheet **128** carries a plurality of electronic components **146**, in addition to third contact pads **148**, on which are fixed at least one and, in the example represented, two inductive sensors **150**. Fixing inductive sensors **150** to third contact pads **148** allows these inductive sensors **150** to be connected, via flexible printed circuit sheet **128**, to a power source and to a microprocessor (not represented) housed inside the portable object. The power source will supply inductive sensors **150** with the energy required to operate, and the microprocessor will receive and process the signals supplied by inductive sensors **150**.

The free portion **144** of flexible printed circuit sheet **128** is connected to the rest of flexible printed circuit sheet **128** by two strips **152**, which allow free portion **144** to be folded around the assembly of upper frame **36** and lower frame **2**, and then folded down against lower face **112** of lower frame **2**, so that inductive sensors **150** penetrate two housings **156** arranged in lower surface **112** of lower frame **2**. Thus positioned inside their housings **156**, inductive sensors **150** are precisely located under magnetized ring **18**, which ensures reliable detection of the direction of rotation of control stem **4**.

Once free portion **144** of flexible printed circuit sheet **128** has been folded down against lower frame **2** (see FIG. **17**A), the assembly is covered by a holding plate **158**, provided with at least one elastic finger **160** (two in the example represented), which exerts on inductive sensors **150** an elastic pressure force directed vertically upwards so as to press these inductive sensors **150** against the bottom of their housings **156** (see FIG. **17**B). Elastic fingers **160** press on flexible printed circuit **128** preferably at the place where inductive sensors **150** are fixed. Holding plate **158** is fixed to plate **140**, for example by means of two screws **162**.

Control stem **4** is carried by lower frame **2** which acts as a cradle. Likewise, the two inductive sensors **150** are disposed inside two housings **156** provided in said lower frame **2**, and are pressed against the bottom of these housings **156** by one or two elastic fingers **160** (see FIG. **18**). Consequently, the relative positioning precision of inductive sensors **150** and magnetized ring **18**, which is rotationally fixedly mounted relative to control stem **4**, is determined only by the precision with which lower frame **2** is made. The manufacturing precision of lower frame **2**, which is for example made of injected plastic, is sufficient to guarantee the proper positioning of inductive sensors **150** and of magnetized ring **18**, even in the case of large scale production. Further, since inductive sensors **150** are elastically forced against the bottom of housings **156** by elastic finger(s) **160**, this makes it possible to compensate for any play resulting from manufacturing tolerances. These manufacturing tolerances may, in particular, result from the step of soldering Hall-effect components **150** on flexible printed circuit sheet **128**. This soldering operation is performed, for example, in a furnace using a soldering paste deposited on contact pads **148** of flexible printed circuit sheet **128**.

Inductive sensor or sensors **150** each include a sensing element **154** which, in a simplified manner, takes the form of a parallelepiped element sensitive to fluctuations in magnetic induction in a direction S perpendicular to the large side of the parallelepiped (see FIG. **22**). In the example illustrated in FIG. **18**, inductive sensors **150** are preferably oriented such that their sensing element **154** detects a fluctuation in magnetic induction only in vertical direction z. In other words, the inductive sensors are completely insensitive to horizontal components along the orthogonal x and y axes of magnetic induction.

In the case where a single inductive sensor **150** is provided (see FIG. **19**), the amplitude of rotation and the position of control stem **4** may be determined with only average precision. Indeed, when magnetized ring **18** rotates as a result of actuation of control stem **4**, inductive sensor **150** produces a sinusoidal signal whose amplitude of variation fluctuates according to the value of the angle concerned. In an area close to the value $\pi/2$, for example, the sinusoidal signal varies very little, so that control stem **4** can be rotated to quite a large extent without any significant modification in the signal provided by inductive sensor **150**. The position and displacement of control stem **4** can therefore only be detected with average precision. However, within an area close to value π, the sinusoidal signal fluctuates sharply, such that the amount of rotation and the position of control stem **4** can be determined with high precision. In the case where one can be satisfied with average precision in the detection of the position and amount of rotation of control stem **4**, the system described above is entirely suitable. However, in the case where very high measurement precision is required, it is preferable to equip the portable object according to the invention with two inductive sensors **150** (see FIG. **18**). Indeed, by providing for the use of two inductive sensors **150**, it is possible to determine both the amplitude and the direction of rotation of control stem **4** with increased precision. Thus, the two inductive sensors **150** are arranged at an equal distance from the centre of rotation O of magnetized ring **18**, symmetrically with respect to a plane P passing through the centre of rotation O of magnetized ring **18**. Preferably, the two inductive sensors **150** are arranged with respect to control stem **4** such that, when magnetized ring **18** rotates as a result of actuation of control stem **4**, the two inductive sensors **150** produce sinusoidal signals $\sin(x)$ and $\sin(x+\delta)$ that are out of phase relative to each other by an angle δ comprised between 60° and 120°, and preferably equal to 90°. To calculate the relative arrangement of the two inductive sensors and magnetized ring **18**, it is possible, for example, to perform successive iterations by means of finite element calculation software.

Owing to the phase shift δ between the sinusoidal measurement signals $\sin(x)$ and $\sin(x+\delta)$ produced by the two inductive sensors **150**, when the arctangent function of the ratio between these two measurement signals is calculated, a straight line is obtained. Consequently, it is possible, from a rotary motion of control stem **4**, to obtain a linear response from the system formed by control stem **4**, magnetized ring **18** and the two inductive sensors **150**. This linearization of the rotation of control stem **4** advantageously permits absolute detection of the position of control stem **4**. In other words, it is possible at any time to know the direction of rotation and the position of control stem **4**. Further, owing to phase shift δ, there is constantly a situation where, when sinusoidal measurement signal $\sin(x)$ produced by one of the two inductive sensors **150** varies slightly, the other sinusoidal signal $\sin(x+\delta)$ varies more sharply and vice versa, such that the ratio between these two signals always gives precise information about the rotation of control stem **4**.

It was mentioned above that inductive sensors **150** were preferably oriented such that their sensing element only detects fluctuations in magnetic induction along the vertical axis z. This component of magnetic induction is the sum of inductions along axis z generated by magnetized ring **18** and by the magnetic field outside the portable object. However, given that inductive sensors **150** are very close to each other, the influence exercised thereon by the external magnetic field is substantially the same for both inductive sensors **150**. Consequently, calculating the ratio between the two sinusoidal signals $\sin(x)$ and $\sin(x+\delta)$ eliminates the component of magnetic induction due to the magnetic field outside the portable object. The response of the system formed by control stem **4**, magnetized ring **18** and inductive sensors **150** is thus totally independent of the external magnetic field, and it is not necessary to take steps to magnetically shield the portable object. Likewise, the response of the system is independent of temperature insofar as the temperature has the same effect on both inductive sensors.

It goes without saying that the present invention is not limited to the embodiment that has just been described and that various simple modifications and variants can be envisaged by those skilled in the art without departing from the scope of the invention as defined by the annexed claims. In particular, the magnetized ring concerned here is preferably a bipolar ring but it may also be a multipolar magnetized ring. The dimensions of the magnetized ring could also be extended so that it corresponds to a hollow cylinder.

NOMENCLATURE

1. Control device
2. Lower frame
4. Control stem
X-X. Longitudinal axis of symmetry
6. Rear end
8. Actuation crown
10. Front end
12. Square section
14. Magnetic assembly
16. Smooth bearing
18. Magnetized ring
20. Support ring
22*a* First section
D**1**. First external diameter
22*b*. Second section
D**2**. Second external diameter
24. Shoulder
26. Square hole
28. Cylindrical housing
D**3**. First internal diameter
30. Annular hole
D**4**. Second internal diameter
D**5**. Third external diameter
32. Circular collar
34*a* First groove
34*b*. Second groove
36. Upper frame
38. First receiving surface

40. Second receiving surface
42. Hole
44*a*, **46***a* Third and fourth undercut surfaces
44*b*, **46***b* Complementary undercut surfaces
48. Case middle
49. Back
50. Annular collar
52. Cylindrical section
54. Back section
56. Groove
58. Position indexing plate
60. Curved portion
62. Guide arm
64. Studs
66*a*, **66***b* Fingers
68. Rim
70. Apertures
72. Profile
74*a* First recess
74*b*. Second recess
76. Peak
78. Ends
80. Positioning spring
82. Arms
84. Base
86. Arbors
88. Displacement limiting spring
90. Central portion
92. Pair of elastic arms
94. Pair of elastic arms
96. Stiff lugs
98. Disassembly plate
100. Straight segment
102. First crosspiece
104. Second crosspiece
106. Lugs
108. Housing
110. Hole
112. Lower face
114. First ramp profile
α First slope
116. Transition point
118. Second ramp profile
β Second slope
120*a*, **120***b* First and second contact spring
122*a*, **122***b* First and second cavity
124. Contact lugs
126. First contact pads
128. Flexible printed circuit sheet
130*a*, **130***b* Third and fourth contact springs
132*a*, **132***b* Third and fourth cavities
134. Increase in diameter
136. Holes
138. Second contact pads
140. Plate
142. Cutout
144. Free portion
146. Electronic components
148. Third contact pads
150. Inductive sensors
152. Strips
154. Sensing element
156. Housings
158. Holding plate
160. Elastic fingers
162. Screws

The invention claimed is:

1. A portable object comprising:

a control stem, actuation of which in rotation can control at least one electronic or mechanical function of the portable object;

a magnetized ring driven in rotation by the control stem; and

two inductive sensors configured to detect a rotation of the control stem and a position of the control stem, the two inductive sensors configured to be sensitive to a variation in magnetic induction produced by rotation of the magnetized ring in only two directions in space, which are parallel to each other,

wherein the two inductive sensors are arranged at an equal distance from a center of rotation of the magnetized ring, symmetrically with respect to a plane passing through the center of rotation of the magnetized ring.

2. The portable object according to claim **1**, wherein the two inductive sensors are sensitive to a variation in magnetic induction only in a vertical direction.

3. The portable object according to claim **1**, wherein the two inductive sensors are arranged with respect to the control stem such that, when the magnetized ring rotates as a result of actuation of the control stem, the two inductive sensors produce signals that are phase shifted with respect to each other by a value between 60° and 120°.

4. The portable object according to claim **2**, wherein the two inductive sensors are arranged with respect to the control stem such that, when the magnetized ring rotates as a result of actuation of the control stem, the two inductive sensors produce signals that are phase shifted with respect to each other by a value between 60° and 120°.

5. The portable object according to claim **1**, wherein the object includes a frame configured to serve as a cradle for the control stem, the inductive sensors being disposed inside at least one housing arranged in the frame inside which the sensors are held by an elastic device.

6. The portable object according to claim **5**, wherein the two inductive sensors are disposed inside two distinct housings arranged in the frame.

7. The portable object according to claim **5**, wherein the portable object includes a holding plate including at least one elastic finger which, by pressure on the inductive sensors, holds the inductive sensors inside at least one housing in which the sensors are disposed.

8. The portable object according to claim **6**, wherein the portable object includes a holding plate including at least one elastic finger which, by pressure on the inductive sensors, holds the inductive sensors inside at least one housing in which the sensors are disposed.

9. The portable object according to claim **7**, wherein the holding plate includes two elastic fingers and the inductive sensors are fixed to a printed circuit sheet on which the elastic fingers press at locations where the inductive sensors are fixed.

10. The portable object according to claim **8**, wherein the holding plate includes two elastic fingers and the inductive sensors are fixed to a printed circuit sheet on which the elastic fingers press at locations where the inductive sensors are fixed.

11. The portable object according to claim **9**, wherein the printed circuit sheet is flexible and the sheet is folded down onto the frame such that the inductive sensors are disposed inside the housings.

12. The portable object according to claim **10**, wherein the printed circuit sheet is flexible and the sheet is folded down onto the frame such that the inductive sensors are disposed inside the housings.

13. The portable object according to claim **11**, wherein the elastic fingers immobilize the inductive sensors in a vertical direction.

14. The portable object according to claim **12**, wherein the elastic fingers immobilize the inductive sensors in a vertical direction.

15. The portable object according to claim **13**, wherein the elastic fingers are configured to force the inductive sensors against a bottom of the housings inside which the sensors are disposed.

16. The portable object according to claim **14**, wherein the elastic fingers are configured to force the inductive sensors against a bottom of the housings inside which the sensors are disposed.

17. A method for detecting a position of a control stem, actuation of which in rotation controls at least an electronic or mechanical function of a portable object including the control stein, a magnetized ring driven in rotation by the control stem, the rotation of the control stein and the position of the control stem being detected by two inductive sensors configured to be sensitive to a variation in magnetic induction produced by rotation of the magnetized ring in only one direction in space, the two inductive sensors being arranged at an equal distance from a center of rotation of the magnetized ring, symmetrically with respect to a plane passing through the center of rotation of the magnetized ring, the method comprising:

calculating an arctangent function of the ratio between signals produced by each of the inductive sensors to determine a direction of rotation and a position of the control stem.

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